U.S. Fish & Wildlife Service

HABITAT MANAGEMENT PLAN FOR

BAYOU SAUVAGE NATIONAL WILDLIFE REFUGE NATIONAL WILDLIFE REFUGE

Orleans Parish, Louisiana

Artwork by Larry Wilson

Southeast Region

Bayou Sauvage Lake National Wildlife Refuge

Habitat Management Plan

U.S. Department of the Interior
Fish and Wildlife Service
Southeast Region

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Executive Summary

The 24,738-acre Bayou Sauvage National Wildlife Refuge (NWR) is one of eight refuges in the Southeast Louisiana National Wildlife Refuge Complex (Complex) that encompasses over 160,000 acres of open and impounded marshes, maritime forests, hardwood bottomlands, pine flatwoods, barrier islands, rivers, bayous, and open water. Thousands of waterfowl, as well as many species of shorebirds, wading birds, and songbirds, pass through the Complex each year. The Complex supports a diverse array of other wildlife, including threatened and endangered species. This Habitat Management Plan (HMP) provides a long-term vision and specific guidance on managing habitat for the resources of concern at Bayou Sauvage NWR for the next 15 years.

The HMP formalizes current management at Bayou Sauvage NWR and incorporates many of the habitat goals, objectives, and strategies described in the Bayou Sauvage Comprehensive Conservation Plan (CCP) (USFWS 2009a). The HMP identifies resources of concern for the refuge and lays out habitat management goals, objectives, and strategies to conserve and manage them. Goals and objectives are based on the habitat requirements of resources of concern, historic conditions, site capability, and current vegetation.

Most habitat goals and objectives will be met by continuing current management. Our highest priority will be to continue to provide high-quality intermediate and brackish emergent marsh for waterfowl, shorebirds, waterbirds, and marsh birds, primarily through water level management in impoundments and restoration of marshes lost due to Hurricane Katrina. Additionally, some of our efforts will be focused on reforesting areas also lost due to the storm.

As conditions are likely to change over the next 15 years, the refuge will use adaptive management to respond to changing conditions that impair our ability to achieve habitat objectives or to refine habitat objectives, as needed.

Recommended Citation:

U. S. Fish and Wildlife Service. 2011. Bayou Sauvage National Wildlife Refuge habitat management plan. U.S. Fish and Wildlife Service. Atlanta, GA. 96 pp.

I. Introduction

Since the establishment of Pelican Island National Wildlife Refuge in 1903, the U.S. Fish and Wildlife Service (Service) and its antecedents have managed habitat for fish, wildlife, and plants for the benefit of the American people. Over the past 110 years, the National Wildlife Refuge System (Refuge System) has grown from that small beginning to a nationwide network of lands and waters totaling over 150 million acres on which wildlife comes first. Now, as the Refuge System enters its second century, the Service faces unprecedented challenges, including global climate change, rapid loss of coastal wetlands, accelerating conversion of natural habitats, and a flood of exotic invasive species that shows no sign of abating. If it is to be successful, the Service must reach out to partners, learn to adapt, and think, plan, and act at scales matching those of the challenges it faces.

Planning is recognized as an integral part of Strategic Habitat Conservation, which the Service has adopted as the framework for accomplishing its mission. Refuges are the primary vehicle through which the Service's new strategic emphasis is put into practice. This Habitat Management Plan (HMP) serves as the final link from the strategic vision set forth in the Service's publication "Conserving the Future" (U.S. Fish and Wildlife Service 2011) and telegraphed down through the refuge comprehensive conservation plan. Actions prescribed herein make the vision a reality.

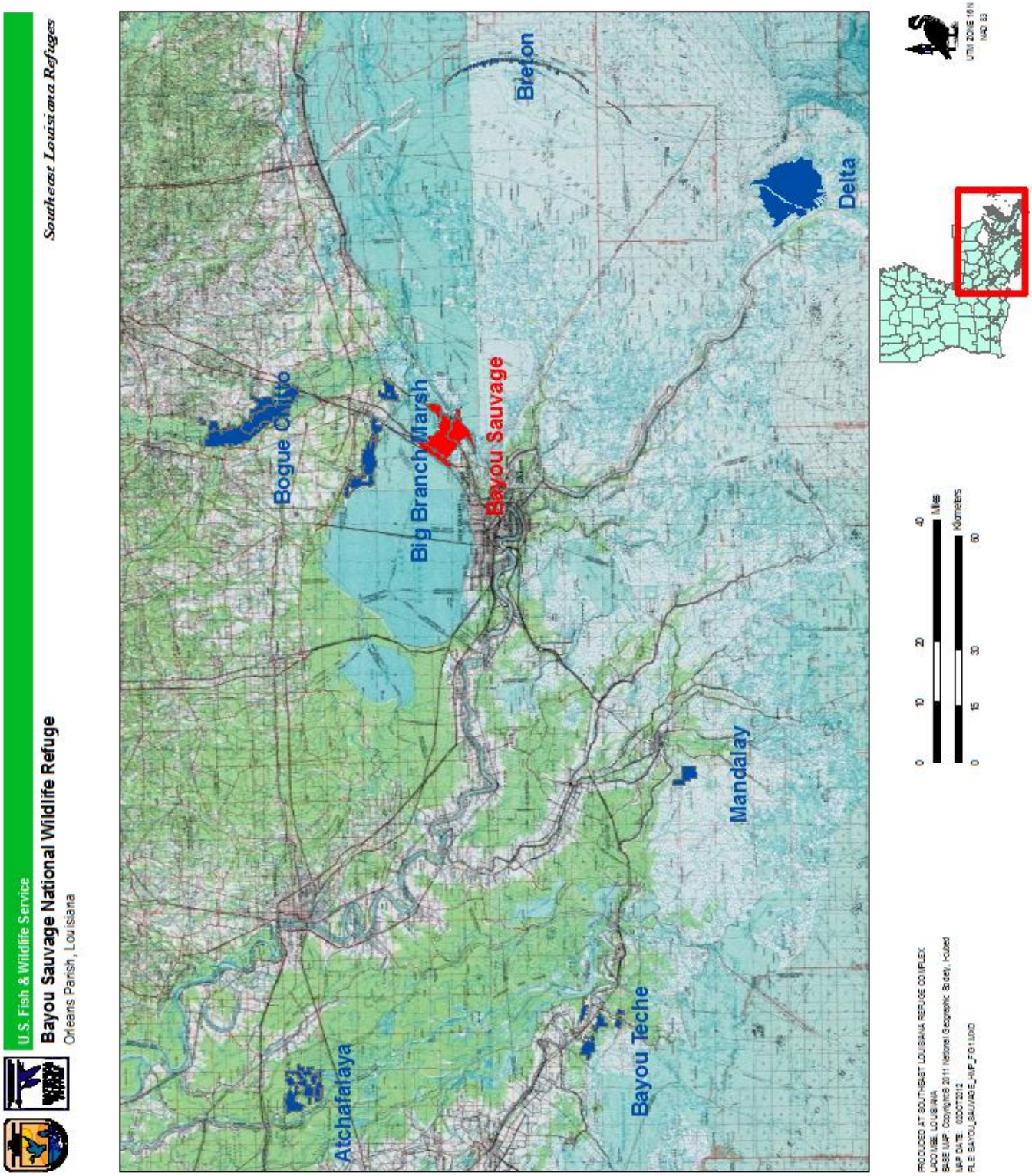
SCOPE AND RATIONALE

Managed by the Service, Bayou Sauvage NWR lies in southeastern Louisiana (Figure 1). The vast wetlands that make up the refuge provide habitat for a variety of birds and other wildlife.

This HMP is a step-down plan of the 2009 Comprehensive Conservation Plan (CCP) for Bayou Sauvage NWR. The wildlife and habitat management goals and objectives contained in the HMP are a reflection of the information and recommendations derived from the Biological Review (U.S. Fish and Wildlife Service 2007a), internal scoping within the Service, and information and recommendations gathered from the public and governmental partners during public scoping for the CCP.

Habitat management plans are dynamic working documents that provide refuge managers with a decision-making framework, guidance for the management of refuge habitat, and long-term vision, continuity, and consistency for habitat management on refuge lands. Each HMP incorporates the role of refuge habitat in international, national, regional, tribal, state, ecosystem, and refuge goals and objectives. It also guides analysis and selection of specific habitat management strategies to achieve those habitat goals and objectives by utilizing key data, scientific literature, expert opinion, and staff expertise (620 FW 1).

Figure 1. Bayou Sauvage NWR location among southeast Louisiana refuges



LEGAL MANDATES

The statutory authority for habitat management planning on refuges is derived from the National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge Improvement Act of 1997 (Improvement Act), 16 U.S.C. 668dd - 668ee. Section 4(a)(3) of the Improvement Act states: "With respect to the System, it is the policy of the United States that each refuge shall be managed to fulfill the mission of the System, as well as the specific purposes for which that refuge was established" and Section 4(a)(4) states: "In administering the System, the Secretary shall monitor the status and trends of fish, wildlife, and plants in each refuge." The Improvement Act provides the Service the authority to establish policies, regulations, and guidelines to govern habitat management planning within the Refuge System. This landmark act prepared the way for a renewed vision for the future of the Refuge System where:

- Wildlife comes first
- Refuges are anchors for biodiversity and ecosystem-level conservation
- Lands and waters of the Refuge System are biologically healthy
- Refuges are national and international leaders in habitat management and wildlife conservation

HMPs comply with all applicable laws, regulations, and policies governing the management of the Refuge System. The lifespan of an HMP is 15 years and parallels that of refuge CCP. HMPs are reviewed every 5 years, utilizing peer review recommendations, as appropriate, in the HMP revision process or when initiating CCPs.

REFUGE PURPOSES

The purposes of a national wildlife refuge, as established by Congress or the Executive Branch, are the barometer by which all actions on that designated public land are measured. Habitat management, public use, and all other programs are required to fulfill the established purposes of the refuge. Bayou Sauvage NWR was established in 1990 with the following purposes:

(1) To enhance the populations of migratory, shore, and wading birds within the refuge; (2) to encourage natural diversity of fish and wildlife species within the refuge; (3) to protect the endangered and threatened species and otherwise to provide for the conservation and management of fish and wildlife within the refuge; (4) to fulfill the international treaty obligations of the United States respecting fish and wildlife; (5) to protect the archaeological resources of the refuge; (6) to provide opportunities for scientific research and environmental education, with emphasis being given to ecological and other values of wetlands; and (7) to provide opportunities for wildlife-dependent public uses and recreation in an urban setting. Further, 100 Stat. 3590, dated November 10, 1986, states for “the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations contained in various migratory bird treaties and conventions" 16 U.S.C. 3901(b), 100 Stat. 3583 (Emergency Wetlands Resources Act of 1986); and
“(1) To protect, enhance, restore, and manage an appropriate distribution and diversity of wetland ecosystems and other habitats for migratory birds and other fish and wildlife in North America; (2) to maintain current or improved distributions of migratory bird populations; and (3) to sustain an abundance of waterfowl and other migratory birds consistent with the goals of the North American Waterfowl Management Plan and the international obligations contained in the migratory bird treaties

and conventions and other agreements with Canada, Mexico, and other countries" 16 U.S.C. 4401 2(b) (North American Wetlands Conservation Act 1986).

In addition to the specific purposes that were established for each refuge, the Improvement Act provides clear guidance for the mission of the Refuge System and priority wildlife-dependent public uses. The act states that each refuge will:

- Fulfill the mission of the National Wildlife Refuge System;
- Fulfill the individual purposes of each refuge;
- Consider the needs of wildlife first;
- Fulfill requirements of comprehensive conservation plans that are prepared for each unit of the Refuge System;
- Maintain the biological integrity, diversity, and environmental health of the Refuge System; and
- Recognize that wildlife-dependent recreation activities, including hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation, are legitimate and priority public uses; and allow refuge managers authority to determine compatible public uses.

VISION STATEMENT

The vision statement that was developed for the refuge during the CCP process reads as follows:

Bayou Sauvage National Wildlife Refuge, which includes a diversity of flora and fauna, provides habitat for the protection of fish and wildlife and provides opportunities for fish and wildlife-dependent public use and recreation adjacent to a major urban center. Staff and volunteers, with the active participation of partners, strive to maintain, identify, conserve, manage, and enhance refuge habitats to increase public awareness of environmental issues affecting the refuge. The management of wildlife and habitat on the refuge is an active, science-driven, comprehensive endeavor that includes research projects to meet information needs of the refuge, and aims to conserve the natural health and beauty of the land for future generations.

RELATIONSHIP TO OTHER PLANS

REFUGE PLANS

Comprehensive Conservation Plan: The CCP was finalized in 2009 and includes broad goals and objectives for management over a 15-year period. The purpose of this HMP is to provide more specific guidance that will facilitate the selection of prescriptions to implement the CCP goals and objectives. In order to maintain consistent strategies for managing wildlife and habitats on the refuge, several other planning documents were used in the development of this HMP.

Fire Management Plan: Bayou Sauvage NWR completed a Fire Management Plan (FMP) in 2008, to guide all fire program activities on the refuge (U.S. Fish and Wildlife Service 2008). Service policy requires an FMP “for each refuge that conducts prescribed burning or on which wildfire may occur." The highest priority of the refuge’s FMP is the protection of life, property, and natural

resources from fire. Prescribed fire is also used as a habitat management tool to maintain grasslands and marshes.

Annual Habitat Work Plan: Each national wildlife refuge prepares an Annual Habitat Work Plan (AHWP) that includes a review of the habitat management activities from the previous year, an evaluation of monitoring programs, and recommendations for habitat management strategies and prescriptions for the coming year. The AHWP documents specific habitat and wildlife management strategies for a specific work year. It is an annual tool to implement and fulfill goals and objectives established in this HMP. The AHWP incorporates adaptive management practices by evaluating success of specific management strategies and prescriptions on a yearly basis.

Other Plans: The refuge has developed several other "step-down" plans that at times have some bearing on habitat management (USFWS 2009a). These include:

- Station Safety 2008
- Law Enforcement 2009
- Marsh and Water Management 1998
- Wildlife Inventory 1996
- Nuisance Animal Control 1993
- Fisheries Management 1991

This HMP includes a broad overview of the future desired habitat conditions for the refuge's vegetative communities.

RECOVERY PLANS

The Service's "National Bald Eagle Management Guidelines" (U.S. Fish and Wildlife Service 2007b) was consulted. Where possible, priority actions identified in these guidelines were incorporated into the strategies of this HMP.

REGIONAL AND NATIONAL BIRD CONSERVATION PLANS

The refuge is an important stopover site for migratory birds. Plans that were consulted for migratory bird habitat priorities are listed below. The refuge contributes to the goals of several of these plans by providing critical wintering, breeding, and foraging habitats for a variety of shorebirds and waterbirds of concern.

North American Bird Conservation Initiative

The North American Bird Conservation Initiative (NABCI) Committee is a forum of government agencies, private organizations, and bird initiatives helping partners across the continent meet their common bird conservation objectives. The committee's strategy is to foster coordination and collaboration on key issues of concern, including coordinated bird monitoring, conservation design, private land conservation, international conservation, and institutional support in state and federal agencies for integrated bird conservation. Four taxonomically delineated bird conservation planning initiatives fall under the auspices of NABCI: the North American Waterfowl Management Plan, the

Partners in Flight North American Landbird Conservation Plan, the United States Shorebird Conservation Plan, and Waterbird Conservation for the Americas: the North American Colonial Waterbird Conservation Plan. Each of these initiatives, in turn, has regional planning efforts which focus in more detail on individual Bird Conservation Regions (BCRs) (North American Bird Conservation Initiative, no date) or groups of BCRs. Bayou Sauvage NWR contributes to the goals of each of the relevant regional plans and of the NABCI by participating in the Gulf Coast Joint Venture and by contributing directly to bird conservation through the actions detailed in this plan.

North American Waterfowl Management Plan

The North American Waterfowl Management Plan (NAWMP Committee 2004) originated as a joint effort of Canada and the United States in 1986. In 1994, Mexico became a participant. The NAWMP calls for restoration of wetland habitats in the three nations in order to allow waterfowl populations to rebound to levels measured in the 1970s.

Joint Ventures, which are regional partnerships of individuals, private organizations, and government agencies, were formed under the auspices of NAWMP. Bayou Sauvage falls within the area covered by the Gulf Coast Joint Venture (GCJV). These organizations have agreed to work together to implement all of the relevant bird conservation plans in their geographic areas (North American Bird Conservation Initiative, no date).

The GCJV is divided geographically into six initiative areas, one of which is the Mississippi River Coastal Wetlands Initiative (MRCWI) area of southeastern Louisiana. The goal of the Mississippi River Coastal Wetlands Initiative (Wilson et al. 2002) is to "provide wintering and migration habitat for significant numbers of dabbling ducks, diving ducks, and snow geese, as well as year-round habitat for the mottled duck."

Bayou Sauvage NWR will contribute to the goals of the NAWMP, GCJV, and MRCWI area by providing 20,976 acres of fresh, intermediate, brackish, and saline marsh to sustain wintering waterfowl. Mottled ducks (*Anas fulvigula*) are also a focus of the GCJV (Wilson 2007). Bayou Sauvage NWR provides important year-round habitat for this species. A critical need identified in the MRCWI Implementation Plan is to protect and restore coastal marshes. Actions proposed for Bayou Sauvage NWR are focused on this goal.

North American Waterbird Conservation Plan

The North American Waterbird Conservation Plan (Kushlan et al. 2002) was developed by Waterbird Conservation for the Americas, a group of individuals and organizations having interest and responsibility for conservation of waterbirds and their habitats in the Americas. Bayou Sauvage NWR is located in the Southeast U.S. Regional Waterbird Conservation Planning Area. A regional plan has been developed for the southeastern United States (Hunter et al. 2006). Management at Bayou Sauvage NWR is focused on a major goal of the continental plan, which is to "protect, restore, and manage sufficient high-quality habitat and key sites for waterbirds throughout the year to meet species and population goals." Specific recommendations in the regional plan (Hunter et al. 2006) include restoration of marsh habitat using dredge material, which is an action proposed in this HMP.

U.S. Shorebird Conservation Plan

The United States Shorebird Conservation Plan (Brown et al. 2001) is the product of a partnership involving organizations throughout the United States committed to the conservation of shorebirds. Bayou Sauvage NWR is located within the Lower Mississippi, Western Gulf Coast Shorebird Planning Region, for which a regional plan has been developed (Elliott and McKnight 2000). This plan divides the Gulf Coast Shorebird Planning Region into subregions. Bayou Sauvage NWR falls within the Mississippi River Coastal Wetlands subregion. Bayou Sauvage NWR contributes to the goals of the Lower Mississippi/Western Gulf Coast shorebird conservation plan by providing undisturbed foraging and roosting, non-beach habitat.

Partners in Flight Bird Conservation Plan

The National Fish and Wildlife Foundation led efforts in the 1990s to form the Partners in Flight program to combine resources and knowledge of many people to coordinate and plan landbird conservation in North America. Out of this effort came the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004) and a series of regional plans focused on BCRs, including the Gulf Coastal Prairie region (Vermillion et al. 2008), which includes Bayou Sauvage NWR. Due to its geographic position and (after restoration) maritime forest habitat, Bayou Sauvage NWR serves as stopover habitat for trans-Gulf migrating neotropical songbirds.

LOUISIANA WILDLIFE ACTION PLAN

With funding from the Wildlife Conservation and Restoration Program (WCRP) and the State Wildlife Grants Program (SWG), states were encouraged to write wildlife action plans which lay out their goals and strategies for wildlife conservation for a 10-year period. Louisiana's plan (Lester et al. 2005) was completed in 2005. Input was gathered from stakeholders including academic, government, private industry, forestry and wildlife groups, nonprofits, and individuals. Bayou Sauvage NWR contributes to the goals of this plan by providing marsh, shrubland, and forest habitat for waterfowl as well as nongame birds and other wildlife.

REGIONAL PLANS AND INITIATIVES

Landscape Conservation Cooperatives (LCCs) have been set up by the Service across the United States. These organizations are partnerships between the Service, the U.S. Geological Survey, other federal agencies, state agencies, nonprofit conservation groups, Native American tribes, academic institutions, and other stakeholders. They cover ecologically defined geographical areas which cut across institutional boundaries. LCCs provide information to conservation managers to help them manage as part of an integrated landscape. The refuge falls mostly in the Gulf Coast Prairie LCC, with a small portion in the Gulf Coastal Plains and Ozarks LCC. A development and operations plan was completed in December 2009 for the Gulf Coastal Plains and Ozarks LCC (Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative 2009). It can be accessed at:

http://www.fws.gov/southeast/LCC/GulfPlains/pdf/GCPOLCCDevOpPlanFinal12112009.pdf. The plan for the Gulf Coast Prairie LCC has not been completed at this writing (December 2011).

REGIONAL PLANS AND INITIATIVES

Bayou Sauvage NWR is a component of several regional and ecosystem conservation planning initiatives, which are described in the following paragraphs taken from the refuge CCP (U.S. Fish and Wildlife Service 2009a).

The National Estuary Program, established as part of the 1987 amendments to the Clean Water Act (CWA), seeks to protect and restore 28 designated estuaries of national significance that are deemed to be threatened by pollution, development, or overuse. The Barataria-Terrebonne National Estuary Program focuses on two basin estuaries in southern Louisiana (Barataria to the south of New Orleans, and Terrebonne to the west), between the Mississippi and Atchafalaya Rivers. Federal agencies participating in the planning and assessment efforts include the Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), Department of the Interior (DOI), and United States Department of Agriculture (USDA).

The Harmful Algal Bloom and Hypoxia Research and Control Act (Pub. Laws 105-383 and 108-456) resulted in the establishment of a task force of federal and state agencies with responsibilities over activities in the Mississippi River basin, the Louisiana coastline, and the Gulf of Mexico. The task force includes 8 federal and 10 state agencies. This Mississippi River/Gulf of Mexico Watershed Nutrient Task Force has prepared an *"Action plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico."* The goal is to reduce the so-called "dead zone" in the coastal Gulf by half by 2015, and to reduce nitrogen loading to the Gulf by 30 percent.

As a result of The Pontchartrain Basin Restoration Act, a water management plan is being implemented which establishes environmental monitoring, implements restoration programs, and constructs restoration projects within the Lake Pontchartrain Basin. A partnership of the Lake Pontchartrain Basin Foundation, regional planning organizations, universities, and parish agencies is developing this management plan.

The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), (Pub. Law 101-646), authorizes the development of comprehensive restoration and comprehensive conservation plans for our nation's coastlands. Forty percent of the coastal marshes of the continental United States covered by this law are in Louisiana. In February 2008, there were 164 CWPPRA restoration projects in Louisiana. Details for these restoration projects are available at the following website: *http://www.lacoast.gov/projects/list.asp*. The majority deal with hydrologic management, shoreline protection, and marsh creation. Acting on the impetus of CWPPRA, the Governor's Office of Coastal Activities in Louisiana provides state leadership, direction, and coordination in the development and implementation of policies, plans, and programs, which encourage multiple uses of the coastal zone and achieve a proper balance between development and conservation, restoration, creation, and nourishment of coastal resources. The following programs and activities have been established under this umbrella:

- Coastal Protection and Restoration Authority of Louisiana (CPRA);
- Coastal Wetland Forest Conservation and Use Science (CWFCU);
- Louisiana Coastal Wetlands Conservation and Restoration Task Force; and
- Wetlands Conservation and Restoration Authority.

The CPRA has prepared a master plan, *"Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast,"* to incorporate hurricane protection and protection of coastal wetlands. The CPRA plan marshals Louisiana's Natural Resources and Transportation and Development departments (and other state agencies) to work closely with the Governor's Advisory Commission on Coastal Protection, Restoration, and Conservation and the Louisiana Recovery Authority (LRA) to integrate within a single state authority coastal restoration and hurricane protection.

The CWFCU science working group provides information and guidelines for the long-term use, conservation, and protection of Louisiana's coastal wetland forest ecosystem. *"Coast 2050: Toward a Sustainable Coastal Louisiana"* is a plan prepared by the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority, a task force of federal, state, and local interests, attempting to address Louisiana's massive coastal land loss problem.

The *Louisiana Native Plant Initiative and the Emergency Watershed Protection program* are two programs initiated by the USDA Natural Resources Conservation Service. The former program seeks to conserve imperiled native plants by identifying resource areas and developing partnerships with the Coastal Plain Conservancy, USGS National Wetlands Research Center, Barataria Terrebonne National Estuary Program, Coastal Impact Assistance Program (CIAP), Coastwide Reference Monitoring System (CRMS), and state universities; while the later program removes debris from waterways and downed timber on forest lands.

II. Environmental Setting and Background

As described in the CCP (U.S. Fish and Wildlife Service 2009a), the refuge was established in 1990. Bayou Sauvage NWR is in eastern Orleans Parish, Louisiana, and is entirely situated within the corporate limits of the city of New Orleans. It is the largest national wildlife refuge located in an urban area of the United States and is one of the last remaining marsh areas adjacent to the south shores of Lakes Pontchartrain and Borgne. The refuge consists of 24,738 acres of wetlands and is bordered on three sides by water: Lake Pontchartrain to the north, Chef Menteur Pass to the east, and Lake Borgne to the south. The western side of the refuge is bordered by the Maxent Canal and lands that support maritime hardwood forest habitat and exotic species such as Chinese tallow *(Triadica sebifera)* and chinaberry *(Melia azedarach).* Un-leveed portions of the refuge consist of estuarine tidal marshes and shallow water. The Hurricane Protection Levee System, along with roadbeds, created freshwater impoundments that altered the plant communities as well as the fish communities within these impoundments. Small forested areas exist on the low, natural ridges formed along natural drainages and canals.

LOCATION

Located in Orleans Parish, Bayou Sauvage NWR lies approximately 18 miles northeast of the city of New Orleans along the eastern shore of Lake Pontchartrain (Figure 1). The refuge headquarters is located in Lacombe, Louisiana. The refuge covers 24,738 acres.

MANAGEMENT UNITS

The refuge consists of nine water management units made up of intermediate and brackish marsh that are situated between Lakes Pontchartrain and Borgne (Figure 2, Table 1). The units range between 525 and 6,000 acres. Units 1, 7, 8, and 9 are tidally influenced brackish marsh. They are located outside any levee system, and water regimes are uncontrolled. Management of these units primarily consists of shoreline protection and large scale marsh restoration projects.

Units 2, 3, 4, 5, and 6 are located inside a system of levees. Water regimes are semi-controllable through a series of flapgate and stoplog structures. Four, 48-inch pumps, located on the east side of Units 4, 5, and 6, are used to dewater the impounded units but cannot be used to flood the units. Currently, the only water source to flood impounded units, other than rainwater, is Lake Pontchartrain. Salinities of Lake Pontchartrain water fluctuate throughout the year, depending on rainfall, and should not be used for flooding when salinities exceed 5.0 ppt.

Figure 2. Bayou Sauvage NWR management units

Table 1. Current management unit descriptions for Bayou Sauvage NWR, Orleans Parish, Louisiana

Unit	Size (acres)*	Levee-protected?	Description
1a	4,871	no	Brackish marsh bordering Lake Pontchartrain and Chef Pass. This unit encompasses former Bayou Chevee, and has a relatively high rate of shoreline erosion and marsh loss. A shoreline protection project was completed in 2001 through CWPPRA, constructing an 8,810-foot rock dike along the eastern edge of the unit (PO-22). The former Bayou Sauvage runs along the south boundary of this unit, which historically supported large stands of cypress and other tree species along the natural levee.
1b	256	no	Brackish marsh bordering Lake Pontchartrain. This unit has experienced significant land loss.
2	3,188	yes	Managed as intermediate marsh, with intermediate marsh, scrub-shrub, and coastal hardwoods habitat types. This is considered a control unit in determining effects of a CWPPRA hydrologic restoration project (PO-16/18). This unit may be dewatered using a series of screw gates located on the hurricane protection levee on the northeastern side of the unit.
3	6,245	yes	Managed as intermediate marsh, with intermediate to brackish marsh, scrub-shrub, and coastal hardwoods habitat types. A series of pipeline canals traverse this unit, creating spoil banks, as well as permanently flooded habitats within the canals. The former Bayou Sauvage runs along the southern boundary of this unit, which historically supported large stands of cypress and other trees species along its banks. The former Turtle Bayou traverses the northeastern portion this unit, which also historically supported a large stand of cypress trees. The open-water area in the center of this unit, Blind Lagoon, continues to grow in size. This unit may be dewatered through three flashboard risers on the western side of the unit or through Unit 4.
4	570	yes	Intermediate to brackish marsh, scrub-shrub, and coastal hardwoods. Located between U.S. Highway 11 and the New Orleans Hurricane Protection Levee, may serve as a route to dewater Unit 3 using a pump station located on the hurricane protection levee.
5	1,861	yes	Managed as intermediate marsh, with intermediate to brackish marsh, scrub-shrub, and coastal hardwoods. This unit encompasses the former Bayou Thomas and may be dewatered using a flashboard riser on the western side of the unit or a pump station located on the hurricane protection levee on the eastern side of the unit. The salinity levels in this unit remain relatively high (>5 ppt), due to past hurricanes and previous events that led to the influx of brackish water.
6	1,806	yes	Primarily open water, intermediate to brackish, with some scrub-shrub and coastal hardwoods. This unit may be dewatered using a flashboard riser on the western side of the unit or a pump station located on the hurricane protection levee on the eastern side of the unit. The salinity levels in this unit remain relatively high (>5 ppt), due to past hurricanes and previous events that led to the influx of brackish water.
7a	1,830	no	Brackish marsh located between the Intracoastal Waterway and Lake Borgne.

Unit	Size (acres)*	Levee-protected?	Description
7b	1,040	no	Brackish marsh located between the Intracoastal Waterway and Lake Borgne. The eastern boundary borders Chef Pass. The former Intracoastal Waterway bisects this unit.
7c	633	no	Brackish marsh located between the CSX Railroad and the Intracoastal Waterway. It is bordered on the east side by the Hurricane Protection Levee and on the west side by Chef Pass. The former Bayou Thomas, which was tidally influenced until levee construction in 1957, bisects this unit.
8	644	no	Brackish marsh located between the former Bayou Sauvage and the CSX Railroad. U.S. Highway 90 bisects this unit. It is bordered on the west side by the Hurricane Protection Levee and on the east side by the Venetian Isles subdivision and Chef Pass.
9	2,027	no	Brackish marsh bordered by Lake Pontchartrain and U.S. Highway 90. This unit was acquired in 2007. This unit represents a critical component of the East Orleans Land bridge along U.S. Highway 90.

PHYSICAL FEATURES

CLIMATE

Climate in this region is subtropical with mild winters and hot, humid summers. Temperatures at New Orleans (Audubon Park) average 83.3°F in July and 54.0°F in January. Frost-free (i.e., ≥ 32°F) period exceeds 331 days in 50 percent of years, and in 30 percent of years, no freezes occur (NOAA 2012). Sporadic afternoon thunderstorms occur almost daily in the summer, with rainfall averages of 61.03 inches per year. The maximum 24-hour rainfall for the area is 10.0 to 10.5 inches, with a recurrence interval of 25 years. The New Orleans area is among the most vulnerable in the country when it comes to hurricanes (Pielke and Pielke 1997).

GEOLOGY AND TOPOGRAPHY

The geology and topography of the area is primarily a result of the meandering of the Mississippi and other rivers. Details can be found in the CCP.

HYDROLOGY AND WATER QUALITY AND QUANTITY

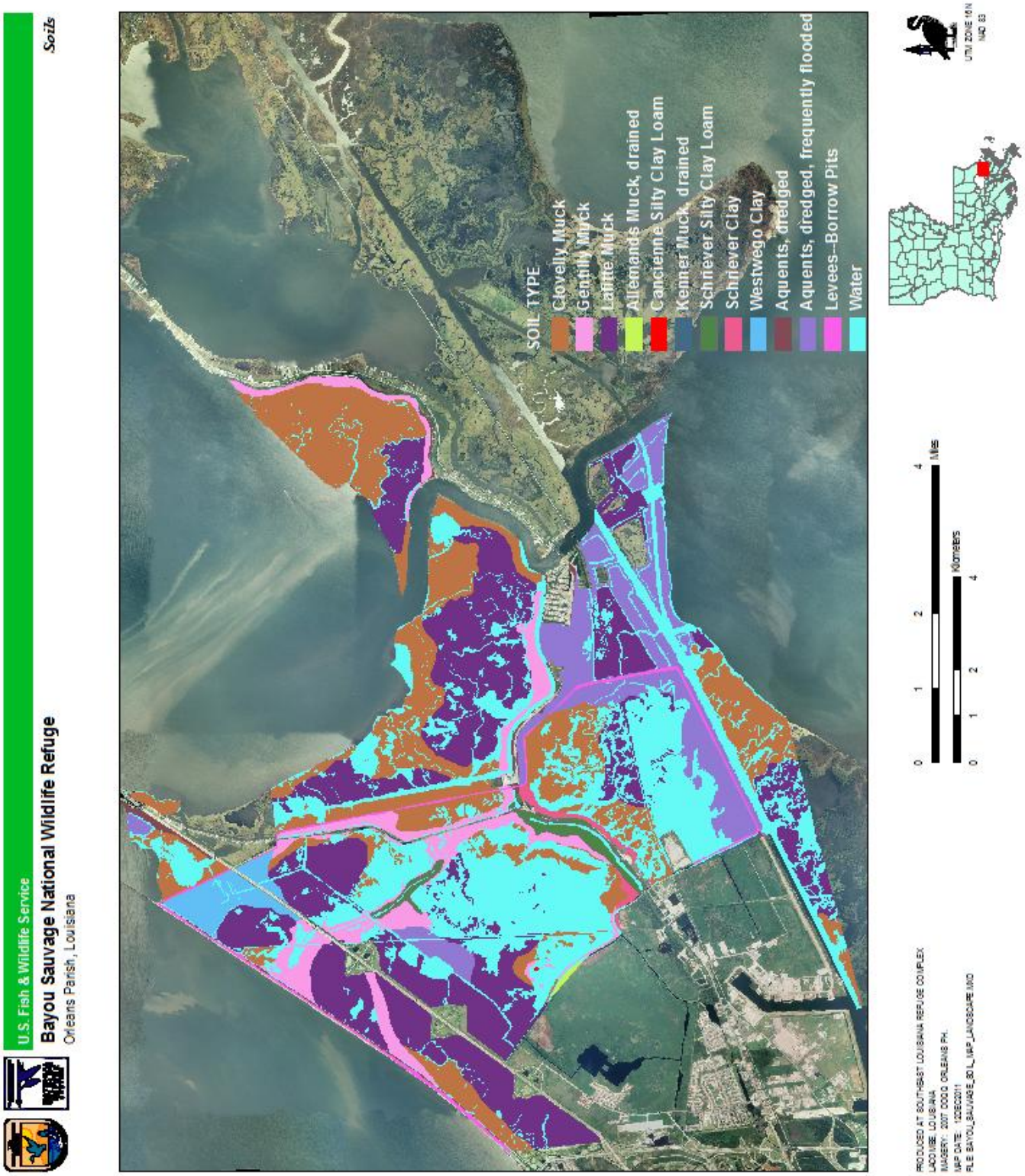
The natural hydrology of the region has been altered considerably by human activities, including construction of roads, railroads, levees, spoil deposits, and canals. Headwater and backwater flood events from alluvial valley tributaries have also been reduced in extent, frequency, and duration. Conversely, the frequency and duration of flooding has increased in all non-leveed areas of the region. In the mid-1950s, natural drainage provided by the Bayou Sauvage freshwater channel network, surface runoff, and estuarine tidal channels was eliminated by construction of hurricane flood protection levees. Urban development adversely affects hydrology and water quality in Bayou Sauvage NWR. There is little long-term water quality data available for the refuge, although the USGS has done several water quality investigations on Lake Pontchartrain, immediately contiguous to the refuge. Storm water runoff (particularly urban storm water runoff in the vicinity of New Orleans) is the largest contributor to the pollution of Lake Pontchartrain, followed by wastewater discharge and industrial runoff.

Each management unit inside the hurricane protection levee is hydrologically connected by at least one water control structure. These management units may ultimately be dewatered via 3 pumping stations or screw gates located on the eastern hurricane protection levee, or via Maxent Canal, located on the western boundary of the refuge (Figure 3).

Rainfall is the main source of water for the impounded marshes. During dry periods, some areas of the refuge may dry up totally. Adding brackish water from Lake Pontchartrain via screw gates can provide some relief, but introducing too much brackish water damages freshwater grasses and other plants. Tides on the refuge (outside the levees) have an average diurnal range of 1.0 foot, with a variation from 0.45-foot in Lake Pontchartrain, north of Chef Menteur Pass, to 1.1 feet in Lake Borgne, near the Pass. Salinities in tidal areas generally average about 4 ppt in Lake Pontchartrain and over 5 ppt near the junction of Chef Menteur Pass and the Gulf Intracoastal Waterway, but can reach 20 ppt during dry periods or in storm surges

Figure 3. Bayou Sauvage NWR water management map

Figure 4. Bayou Sauvage NWR soil types (Natural Resources Conservation Service 2012)



Before 2005, water inside the leveed portion of the refuge was basically fresh, and the marsh was and is currently managed as if it were freshwater marsh, though it is now properly classified as intermediate marsh. During Hurricane Katrina (2005), some of the hurricane protection levees failed, three of four refuge pumps were lost, and the screw gate water control structures were compromised. The entire refuge, including relict ridges, was inundated for 4 weeks. After the waters were pumped off or receded, drought conditions lasting more than a year (2006) worsened conditions. Salinity measurements made of water inside the levees ranged from 17 ppt to the upper 20s. Most of the freshwater vegetation was killed, and 80 to 90 percent of the hardwoods subsequently died. An unknown quantity of sea salt remains in the soil column within the leveed portions of the refuge, and it is not known whether or when it will be flushed out.

SOILS

The majority of the refuge soils are in the Clovelly-Lafitte-Gentilly soil association, which is characterized as level, very poorly drained soils that have a thick to thin mucky surface layer underlain by clayey sediments (Figure 4). These soils exist at elevations ranging from 0 to approximately 1 foot above sea level and are naturally flooded most of the year. Only the Bayou Sauvage natural levee ridge, which reaches a maximum height of less than 3 feet above MSL, contains a Schriever soil association, which is slightly better drained. All of the soils on the refuge are poorly suited to construction of roads, buildings, and dry trails, but are ideal for wetland plants and wildlife (Natural Resources Conservation Service 2012).

ECOSYSTEM CONTEXT

Bayou Sauvage NWR is located in the St. Bernard Delta of the Mississippi River, which lies at the southern end of the Lower Mississippi River Ecosystem (LMRE). The LMRE includes the deltaic plain and associated marshes and swamps created by the meanderings of the Mississippi River and its distributaries. Prior to agricultural development, almost all of the Mississippi Delta was covered with floodplain forests. Currently, only about 23 percent is forested, and the remaining forest is highly fragmented.

Bayou Sauvage NWR lies within the Gulf Coast Prairies and Marshes ecoregion of the LMRE. This ecoregion occupies the coastal zone of the Gulf of Mexico and is defined by coastal prairie and marsh communities. Louisiana's coastal marsh areas, in which Bayou Sauvage NWR is found, are primarily composed of brackish and intermediate marsh habitat types (Louisiana Natural Heritage Program 2009). Associated natural communities include cypress and cypress-tupelo swamps, live oak natural levee forests, and some bottomland hardwood forests.

Lake Pontchartrain and adjacent lakes in Louisiana form one of the larger estuaries in the Gulf Coast region (U.S. Geological Survey 2010). The estuary drains the Pontchartrain Basin, an area of over 4,633 square miles situated on the eastern side of the Mississippi River delta plain. Nearly one-third of the state's population lives within the 14 parishes of the basin.

HISTORIC CONDITION OF REFUGE HABITATS

The LMRE includes the deltaic plain and associated marshes and swamps created by the meanderings of the Mississippi River and its distributaries. Prior to the 1920s, the lands that now make up the refuge were annually recharged by flooding of the Mississippi River, which created primarily brackish marsh habitats. Historical maps (1800s) show much of the area, particularly along the banks of Bayou Sauvage and Turtle Bayou heavily wooded with cypress trees (Harris 1989). The greatest changes

resulted from construction of the New Orleans Hurricane Protection Levee system in the 1950s and the subsequent interruption of historic hydrology. Hurricane Katrina hastened the conversion of fresh marsh and forested wetlands to intermediate marsh and open water.

CURRENT HABITAT CONDITIONS

Much of the refuge is located inside massive hurricane protection levees, built to hold back storm surges and prevent flooding in the low-lying city of New Orleans. The levees interrupt natural water flow patterns and challenge refuge managers to maintain productive wetland habitats in this altered environment. A network of pumps and screw gates provides a means of regulating water levels seasonally to encourage the summer growth of emergent graminoid species *(Echinochloa spp., Leptochloa spp., Sacciolepis striata, Panicum spp., and Cyperus spp.)* that provide waterfowl food supplies in winter.

Prior to Hurricane Katrina, the impounded marshes were primarily fresh, with only a small area of intermediate marsh between Turtle Bayou and the East Hurricane Flood Protection Levee and brackish marsh in the tidal wetlands. According to the Post-Hurricane Katrina Refuge Damage Assessment, prior to Hurricane Katrina, the total area of freshwater and brackish marsh (including open water) was 21,717 acres, with the remaining 1,053 acres being upland margins along levees and berms (Ecology and Environment 2007). Comparison of pre- and post-hurricane imagery showed conversion of 658 acres of freshwater and brackish marsh to open water, which amounted to an overall marsh loss of 11 percent. Most of the marsh loss occurred inside the levee system, particularly within Units 3 and 5. Total marsh area lost for these two units was 763 acres, or 21 percent of pre-storm marsh area in these units. This loss was 44 percent of all marsh lost within the refuge (Ecology and Environment 2007).

Between 2005 and 2011, the damaged Hurricane Protection Levee was reconstructed with a 5-foot increase in elevation and associated increase in base width of up to 300 feet. Additionally, the four pump stations were replaced, and new water control structures were installed. This construction resulted in the loss of about 200 acres of intermediate marsh. Mitigation associated with this marsh loss in the form of several restoration projects is currently in planning stages.

Restoration efforts include forest and marsh replanting and the construction of “fences” for holding sediment with organic materials, such as used Christmas trees, coir logs, and hay bales. When sediments build, they can quickly vegetate with submerged aquatics and subsequently various emergent marsh plant species. Sediment deposition, either from beneficial dredge spoil or dedicated dredging, has been considered. The U.S. Army Corps of Engineers may provide dedicated dredge in Unit 6, as a result of mitigation from the rebuilding of the Hurricane Protection Levees. There are no other large-scale dredging projects in the vicinity of the refuge to create a beneficial spoil source. Bayous and drainages within the refuge, which have silted in, could provide small amounts of dedicated dredge material for building up relict ridges.

Several shoreline stabilization projects have been completed in the Bayou Chevee area (Unit 1) using CWPPRA and other funding sources. These projects resulted in the construction of over 2.5 miles of rock dike starting just west of Chef Pass. These projects are designed to slow marsh erosion processes by decreasing wave energies associated with Lake Pontchartrain and Chef Pass. Additionally, by providing protection and stabilization, these projects have created conditions within the protected marsh that are conducive to future large-scale marsh restoration.

The refuge supports 5 general habitat types: open water, brackish marsh, intermediate marsh, scrub-shrub habitat, and coastal hardwood forest (Table 2, Figure 5). Open water habitats occur naturally on the refuge in bayous, sloughs, and ponds, and interspersed with emergent marsh vegetation, both inside and outside of the Hurricane Protection Levees. Brackish or mesohaline marsh occurs mostly outside of the levees along the margins of Lake Borgne and Lake Pontchartrain. Intermediate or oligohaline marsh occurs mostly inside the levee system. Since Hurricane Katrina, little or no true freshwater marsh occurs on the refuge. It is not known when or if enough salt will be flushed out of the soils within the levees to reduce salinities to freshwater marsh levels. Terrestrial habitats are restricted to relatively small areas of the refuge. Scrub-shrub habitat is found in a narrow band between the intermediate marsh and the coastal hardwoods, which occur on the highest sites (other than levees and spoil banks) on the refuge, and on cheniers and natural levees where the elevation can reach more than 2 feet above mean sea level. Artificial aquatic habitats occur in canals and borrow pits, while artificial terrestrial habitats are found on spoil banks, levees, and roadsides on the refuge. Each of the five habitat types are described below, and putative International Vegetation Classification (IVC) System Associations are given. No detailed IVC vegetation mapping has been done on Bayou Sauvage NWR, and the associations listed here are subject to change pending acquisition of actual data.

OPEN WATER

Open water habitats occur interspersed within marsh types as well as in ponds and bayous within the refuge. These areas on Bayou Sauvage NWR are typically shallow, and submerged plant communities, if present, vary with salinity. In lower salinity situations inside the Hurricane Protection Levee System, submerged vascular plants include coontail *(Ceratophyllum demersum)*, water-celery *(Vallisneria americana)*, and southern naiad *(Najas guadalupensis)*. In brackish water, *Ruppia maritima* and water-celery dominate submerged plant communities. This variety of aquatic plant species provides a diverse habitat for aquatic organisms and food for migratory waterfowl. Tens of thousands of waterfowl winter on the refuge. The marshes along Lakes Pontchartrain and Borgne serve as estuarine nurseries for various fish species, crabs, and shrimp. Freshwater lagoons, bayous, and ponds serve as production areas for largemouth bass *(Micropterus salmoides)*, crappie *(Pomoxis spp.)*, bluegill *(Lepomis macrochirus)*, and catfish *(Ictalurus spp.)*.

IVC: Some of this submerged vegetation may map to the *Vallisneria americana* Estuarine Bayou Herbaceous Vegetation Association (CEGL004634), whose associated species include *Ruppia maritima* and *Najas guadalupensis* in Lake Pontchartrain (NatureServe 2012).

BRACKISH MARSH

Brackish marsh is wetland-dominated by emergent, salt-tolerant herbaceous vegetation where salinities average about 8 ppt (Lester et al. 2005) and may range as high as 20 ppt. Brackish marsh is usually found between intermediate marsh and saline marsh or adjacent to brackish open water systems (estuaries). Brackish marshes generally have lower vascular plant diversity than intermediate or fresh marshes. In Louisiana, these marshes are usually dominated by *Spartina patens*, with varying densities of *Distichlis spicata, Schoenoplectus olneyi, S. robustus, Eleocharis parvula, Paspalum vaginatum, Juncus roemarianus, Bacopa monnieri, Spartina alterniflora*, and *S. cynosuroides (Lester et al. 2005).* Other dicot species present in this habitat on Bayou Sauvage NWR include annual saltmarsh aster *(Symphyotrichum subulatum)* and saltmarsh lythrum *(Lythrum lineare)*. Areas of open water alternate with emergent vegetation and provide drainage and water exchange. Submerged aquatic vegetation in open water areas is usually dominated by *Ruppia maritima*.

IVC: This marsh type probably maps to the *Spartina patens – Schoenoplectus (americana, pungens) – (Distichlis spicata)* Herbaceous Vegetation association (CEGL004755) (NatureServe 2012).

INTERMEDIATE MARSH

Intermediate, or oligohaline marsh, generally lies between freshwater marsh and brackish water marsh. Salinities in this habitat range between 3 and 10 ppt, and plant diversity also is intermediate between that of fresh and brackish marsh (Lester et al. 2005). Many of the same species which are found in fresh and brackish marsh are found in this habitat as well, except that the least salt-tolerant species of fresh marsh are absent (i.e., *Panicum hemitomon*, *Typha* spp., *Nymphaea odorata*, and the exotics *Salvinia* spp. and *Eichhornia crassipes*). Dominant emergent plant species in intermediate marsh include *Spartina patens*, *Phragmites australis, Sagittaria lancifolia, Bacopa monnieri, Eleocharis spp., Schoenoplectus olneyi, S. californicus, and S. americanus*. Other plant species found there include *Vigna luteola, Paspalum vaginatum, Panicum virgatum, Panicum dichotomiflorum, Leptochloa fascicularis, Pluchea camphorata, Echinochloa walteri, Cyperus odoratus, Najas guadalupensis, Spartina cynosuroides, Spartina spartinae, and Sacciolepis striata* (Louisiana Natural Heritage Program 2009). *Alternanthera philoxeroides* is a common exotic invader in this habitat type.

IVC: Intermediate marsh at Bayou Sauvage NWR may map to any of several associations given by (NatureServe 2012). In the absence of a vegetation mapping effort, it is not possible to narrow the search further.

SCRUB-SHRUB

These habitats on Bayou Sauvage NWR lie between intermediate marsh and coastal hardwood forest, which is on higher ground. The shrub habitat occurs on Gentilly muck on Bayou Sauvage NWR. It is dominated by eastern baccharis *(Baccharis halimifolia),* with associated species including marsh elder *(Iva frutescens),* waxmyrtle *(Morella cerifera),* and rattlebox *(Sesbania drummondii).*

IVC: This vegetation type probably maps to the *Baccharis halimifolia – Iva frutescens – Morella cerifera – (Ilex vomitoria)* Shrubland association (CEGL003920) (NatureServe 2012).

COASTAL HARDWOOD FOREST

Forested portions of the refuge, occurring on a narrow ridge which follows the former course of Bayou Sauvage, are dominated by live oak *(Quercus virginiana)* and sugarberry *(Celtis laevigata),* with associated tree species including *Gleditsia triacanthos, Ulmus americana*, and other species. Understory shrubs include yaupon *(Ilex vomitoria),* palmetto *(Sabal minor),* and common persimmon *(Diospyros virginiana)*. This vegetation type on Bayou Sauvage NWR was heavily disturbed during the flooding which followed Hurricane Katrina in 2005. Inundation by several feet of brackish water killed most of the overstory, leaving scattered sugarberry and live oaks. Reforestation efforts have included artificial regeneration with green ash *(Fraxinus pennsylvanica),* baldcypress *(Taxodium distichum),* red maple *(Acer rubrum),* silver maple *(A. saccharinum)*, and other species. Chinese tallow is a common invader, and has been the subject of repeated control efforts since 2005. The continued subsidence of the ridges, in addition to the saltwater intrusion due to major storms and an extended drought over the past 15 to 20 years, has continually compromised the integrity of the area to support hardwood communities.

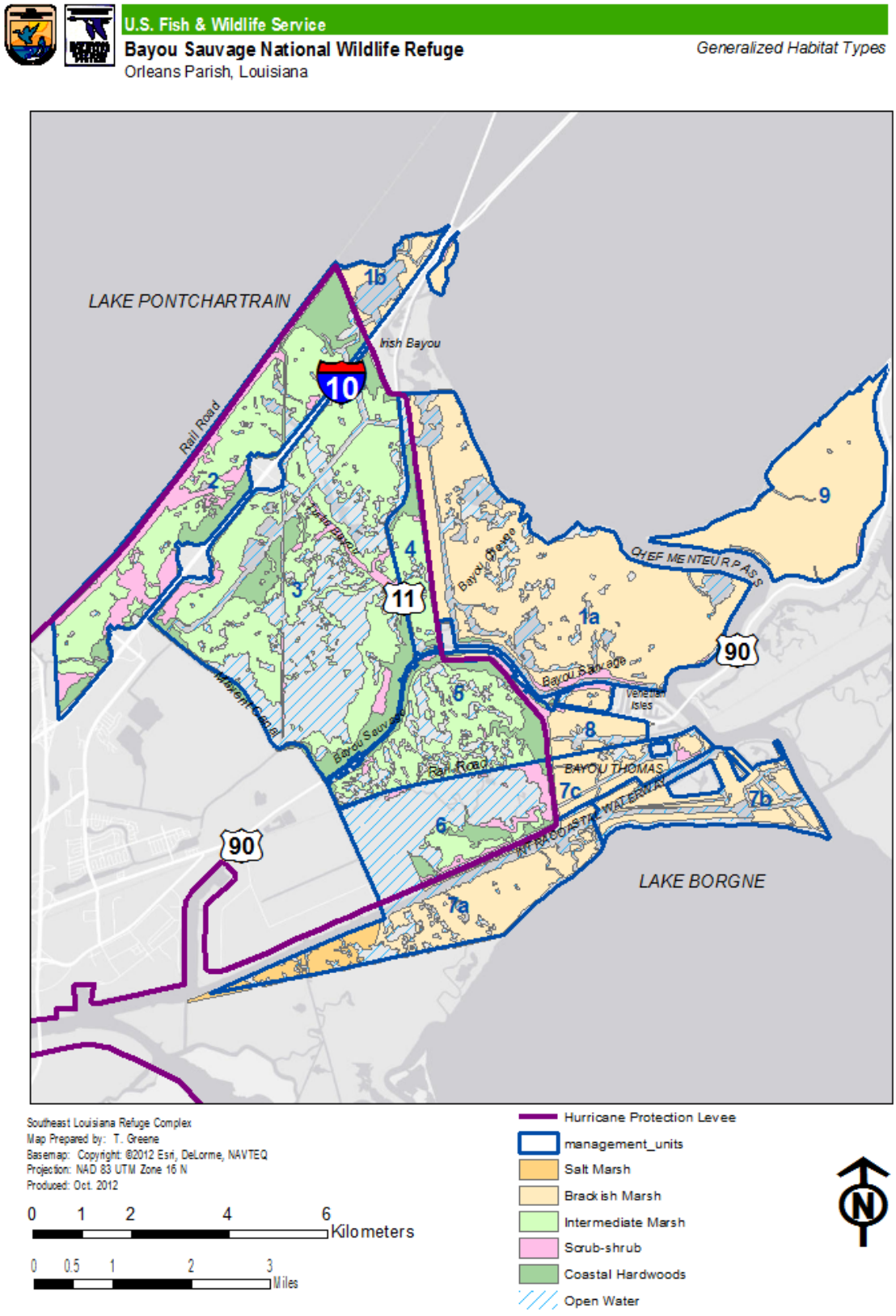
IVC: This forest type probably maps to the *Quercus virginiana – Celtis laevigata /Sabal minor* Forest association (NatureServe 2012).

Table 2. Habitat types and associated acreages found on Bayou Sauvage NWR

Habitat Type	Acres	Management Units	Habitat Conditions
Brackish Marsh	8,676	1a, 1b, 7a, 7b, 7c, 8, 9	Mixture of emergent vegetation with open water ponds, bayous, and mudflats. Dominate vegetation is *S. patens*. Also common are *S. alterniflora*, *S. cynosuroides*, *Aster subulatus*, *Lythrum lineare*, and *Scirpus olneyi*. Salinities generally range from 3 – 20 ppt.
Intermediate Marsh	5,703	2, 3, 4, 5, 6	Mixture of emergent vegetation with open water ponds, bayous, mudflats, and canals. Dominant vegetation is *S. patens*. Other common taxa include other *Spartina spp*., *Panicum dichotomiflorum*, *P. virgatum*, *Leptochloa spp*., *Typha spp*., Bacopa monnieri, and *Sesbania spp*. *Salix nigra* may also be common. Salinities generally range from 0 – 8 ppt.
Open Water	7,044	1a, 1b, 2, 3, 4, 5, 6, 7, 7a, 7b, 7c, 8, 9	Common submerged aquatic vegetation species include *Ceratophyllum demersum*, *Najas guadalupensis*, and *Vallisneria* americana). Salinities generally range from 0 – 20 ppt. Water depth ranges from 0 – 6 feet.
Scrub-shrub	1,351	1a, 2, 3, 4, 5, 6, 7c, 8	Dominant taxa include *Baccharis halimifolia*, *Iva frutescens*, *Phragmites australis*, and *Salix spp*. Common understory species include *Panicum spp*., *Spartina* spp.
Coastal Hardwoods	1,964	1a, 2, 3, 4, 5, 6	Primarily early succession mixed hardwoods and maritime forests. Dominant overstory species include *Quercus virginiana*, *Celtis laevigata*, *Triadica sebifera*, and *Salix nigra*. Common midstory taxa include *Ilex spp*., *Persea palustris*, *Phragmites australis*., *Salix* spp., *Iva spp*., and *Baccharis spp*. Common understory taxa include *Panicum spp*. and *Spartina spp*.

**Acreages were calculated using Geographical Information System and thus are approximate.*

Figure 5. General habitat types on Bayou Sauvage NWR



HABITAT CHANGES FROM HISTORIC TO CURRENT CONDITION

The most pervasive influence on the landscape has resulted from the construction of numerous levees and roads. Prior to these changes, tidal influences and flooding from the Mississippi River maintained a variety of habitats, predominantly marshes ranging in salinity from freshwater to saltwater. In addition to the changes brought about by an altered hydrology, fire-suppression allowed woody species to invade marshes. Although levees significantly changed the wetlands function of many areas, they have, through careful management, become an integral part in maintaining a diversity of habitats on the refuge.

MOIST-SOIL WATER MANAGEMENT

Historically, much of the refuge was fresh to intermediate marsh, recharged by influxes of freshwater from Bayou Sauvage, Lake Pontchartrain, and Bayou St. John during flood events. However, various anthropogenic processes such as levee construction and channelization led to increased marsh loss and saltwater intrusion. Furthermore, construction of the Hurricane Protection Levee System in the 1950s followed by attempts at urban development disrupted the hydrology of the portion of Bayou Sauvage inside the levees.

Currently, the impounded units of the refuge are managed as if they were freshwater moist-soil impoundments. However, due to the highly organic nature of the soils and the lack of a reliable freshwater source, water management within the levee system is a highly complex undertaking, which has been further complicated by the residual salts remaining from Hurricane Katrina. Consequently, the majority of traditional moist-soil management on the refuge is limited to the transitional areas between the scrub-shrub and intermediate marsh habitat types (Table 1 and Figure 4), where salinities and soils (primarily Clovelly and Gentilly mucks) are more conducive to freshwater moist-soil production.

FIRE MANAGEMENT

Fire is a natural process that has played a significant role in dynamics of habitats of Bayou Sauvage NWR. Historically, naturally caused lightning fires and anthropogenic fires burned the forests and marsh surrounding Lake Pontchartrain. Currently, fire management on the refuge consists of both wildfire suppression and prescribed burning activities. Prescribed burning is the application of fire to achieve land use objectives under specific conditions. In contrast, wildfires that occur on the refuge are started by lightning strikes or from human activities under non-prescribed conditions. Wildfires occur every year on the refuge. During the period from 1990 to 2006, there were 101 wildfires that burned over 2,000 acres on the refuge. The majority of the wildfires were human-caused fires rather than natural lightning strikes.

There are many challenges to prescribed burning on Bayou Sauvage NWR. The biggest challenge is managing smoke in the vicinity of a major interstate (I-10) and highways (U.S. 11 and 90), which bisect the refuge. Nearby industrial and residential areas along with downtown New Orleans further complicate smoke management decisions. In addition to the challenges of smoke management, water levels can also limit the window of opportunity for prescribed burning in certain units of the refuge.

Prescribed burning is used as a management tool in units inside the hurricane protection levees. Currently, no prescribed burning is used in the marshes outside the protection levees, primarily because these brackish marshes are subsiding. There is little scientific data to support burning subsiding marshes (Nyman and Chabreck 1995). Within the protection levees, prescribed burning is

used in selected units to encourage more desirable waterfowl food plant species, such as three-square, millet, and foxtail, over undesirable species, such as cattails. In units where native waterfowl foods are abundant, less prescribed burning is applied. Fire effects have been monitored over time at Bayou Sauvage NWR and have shown that the amount of native plant species, such as panicums, foxtails, and millets, has increased over time from the prescribed burning program. Although waterfowl response is usually good after a burn in the marsh, other factors, such as overall health of the marsh or loss of plant materials for sedimentation, can also play a role.

Another challenge to the fire management program of Bayou Sauvage NWR is the amount of debris deposited on the refuge following Hurricane Katrina in 2005. Marsh vegetation rolled up by wind and water formed lines of debris, known as "wrack lines," within the refuge. These lines are mostly made up of the organic materials of the marsh. However, there are also numerous wrack lines in the refuge made up of mostly man-made, wood-based products. These wrack lines occur mainly outside the protection levee system adjacent to the Intracoastal Waterway. Concerns have been expressed over the potential health risks to the public from inhaling smoke generated by burning hazardous materials.

CHANGES ASSOCIATED WITH GLOBAL CLIMATE CHANGE

Anthropogenic climate change, a result of elevation of atmospheric carbon dioxide levels from fossil fuel consumption, widespread deforestation, and release of other "greenhouse gases," such as methane from various sources, is a transformational threat not only to conservation of natural resources, but also to the global human population. Recent observed changes, including elevated mean temperatures, shifts in precipitation patterns, and sea level rise, are almost certainly only harbingers of much worse to come (IPCC 2007). That these changes are anthropogenic is no longer seriously in question; numerous well-designed studies have implicated human activities in elevation of greenhouse gases and other known causes of global climate change (CCSP 2009). For Bayou Sauvage NWR, the most important consequences of climate change are sea level rise and an increase in the frequency and/or intensity of tropical cyclones. Additional consequences will likely be shifts in phenology and species distribution, with more temperate flora and fauna being gradually replaced by subtropical and tropical species.

Because of the uncertainty of the intensity and distribution of impacts caused by global climate change, one of the best management actions the refuge can take is to gather information at regular intervals across the resource spectrum. The goals, objectives, and strategies proposed in the CCP, this HMP, and other step-down plans are an important first step in understanding and monitoring the potential threats related to climate change. The information obtained will help the Service modify and adapt its framework of management tools to protect refuge resources. The following sections summarize some of the potential consequences of climate change on the refuge.

SEA LEVEL RISE ASSOCIATED WITH CLIMATE CHANGE

Global sea level rise has been occurring since the middle of the 19th Century. These observed increases in sea level are a result of temperature increases (i.e., thermal expansion), as well as inputs from melting ice caps in Greenland and Antarctica. In the 20th Century, the rate was approximately 1.7 mm/year (.07 inches/year). Higher rates, up to 4 mm/year (0.16 inches/year) (Bindoff et al. 2007; Church et al. 2001; Meier et al. 2007; Carlson et al. 2008) are predicted for the 21st Century.

Local (i.e., relative) sea level rise along the Louisiana coast is much greater than the global mean because of local, geological subsidence, which has been known for some time (Salinas et al. 1986). Relative sea level change rates near the refuge, as measured at Grand Isle, Louisiana, are close to 9

mm/yr. (0.36 inches/year) (NOAA 2010). A Sea Level Affecting Marshes Model (SLAMM) (Nieves, 2008) indicates that under moderate-to-high sea level change scenarios (+0.5 m, +1.34 m, +1.95 m), most of the refuge, including portions currently within hurricane protection levees, will be open water by 2100. Changes on this magnitude would obviously cause major shifts in the species using the refuge Countering the threat posed by sea level rise (i.e., maintaining approximately the same mix of habitats as are present now) would mean long-term commitments to dedicated dredge projects and/or construction of hardened barriers. These measures are most likely to be taken primarily for the purpose of protecting the Lake Pontchartrain Basin from catastrophic storm surges as the sea advances.

EFFECTS OF CLIMATE CHANGE ON TROPICAL CYCLONES

Tropical cyclones (e.g., tropical storms, hurricanes) are fueled by warm waters in the tropical oceans. Storms which affect the U.S. Gulf coast originate in the tropical North Atlantic Ocean and move westward steered by winds aloft. Recent research has found a strong correlation between surface water temperatures and the intensity of these storms. Warmer ocean temperatures are thus likely resulting in higher wind speeds in tropical cyclones. Interestingly, no increase in storm frequency has been detected (Elsner et al. 2008). It is likely that future large hurricanes, fueled by increasingly warmer waters, will affect the refuge.

CHANGES IN PHENOLOGY AND SPECIES DISTRIBUTION DUE TO CLIMATE CHANGE

Effects of climate change on species and biological communities are difficult to predict, because interactions between future climate change effects and among species are unknown. However, in general, it can be expected that warming temperatures, with concomitant decreases in the frequency and intensity of freezes, will result in pole-ward and elevation shifts of species either able to exploit new areas because of warming and/or unable to use their former ranges due to excessive heat. Migratory species can be expected (and have already been observed) to modify their migration timing in response to changes in temperature regimes. Similar shifts would likely occur as a result of changes in precipitation patterns (McCarty 2001; Parmesan and Yohe 2003; Root et al. 2003; Hannah et al. 2005; Parmesan 2006). A major concern for conservationists is that shifts in migration and species ranges will cause disconnects between coevolved species, which depend on each other such as specialist pollinator/plant interactions or predator/prey relationships, resulting in extirpation or extinction of some species and cascading effects throughout ecosystems (Root et al. 2003).

III. Resources of Concern

INTRODUCTION

The Service is entrusted by Congress to conserve and protect migratory birds and fish, federally listed threatened and endangered species, inter-jurisdictional fishes, and certain marine mammals. These are known as "trust species." In addition to this Service mandate, each refuge has one or more purposes for which it was established that guide its management goals and objectives. Further, refuges support other elements of biological diversity, including invertebrates, rare plants, unique natural communities, and ecological processes, that contribute to biological diversity, integrity, and environmental health at the refuge, ecosystem, and broader scales (601 FW3), (U.S. Fish and Wildlife Service 1999).

Given the multitude of purposes, mandates, policies, regional, and national plans that can apply to a refuge, there is a need to identify the resources of concern and then prioritize those resources that the refuge is best suited to focus on in its management strategies. The following is the process that Bayou Sauvage NWR used to identify priority resources of concern and develop habitat goals, objectives, and strategies to benefit those resources.

The HMP policy (620 FW) defines "resources of concern" as

> "All plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), System mission, or international, national, regional, state, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect 'migrating waterfowl and shorebirds.' Federal or state threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts."

IDENTIFYING RESOURCES OF CONCERN FOR BAYOU SAUVAGE NWR

The following polices, mandates, and sources of information were utilized to develop a list of resources of concern (Table 3) for the refuge:

- Legal Mandates (See Chapter I of this HMP)
- U.S. Fish and Wildlife Service Trust Species
    - Migratory Bird Treaty Act (16 U.S.C. 703–711)
    - Interjurisdictional Fish (FWS Director's Order No. 132, Section 6[c])
    - Marine Mammal Protection Act (16 U.S.C. 13611407)
    - Threatened and Endangered Species Act (16 U.S.C. 1531-1544, December 28, 1973, as amended 1976-1982, 1984, and 1988)
- Biological Integrity, Diversity, and Environmental Health Policy (Integrity Policy, 601 FW 3)

In addition, the refuge prioritized species and their associated habitats to determine what the refuge is best suited to focus on in its management strategies. To guide us in prioritizing this list, we considered the following concepts:

- Achieving refuge purposes and managing for trust resources, as well as biological diversity, integrity, and environmental health, can be addressed through the habitat requirements of "focal species" or species that may represent guilds that are highly associated with important attributes or conditions within habitat types. The use of focal species is particularly valuable when addressing Service trust resources such as migratory birds.
- The BCR plans are increasing their effectiveness at ranking and prioritizing those migratory birds most in need of management or conservation focus. Although all species that make it to a ranked BCR priority list are in need of conservation attention, we selected focal species that were ranked either High or Moderate in Continental Concern with a High to Moderate BCR Responsibility. If there were too many or too few birds with these rankings for a given habitat type, then species with the highest, then high, then medium, final BCR ranking were chosen (See *http://www.nabci-us.org/* for BCR rules used to rank birds).
- Habitat conditions on or surrounding the refuge may limit the capability to support or manage for a potential species of concern. The following site-specific factors were evaluated:
    - Patch size requirements;
    - Habitat connectivity;
    - Compatibility of surrounding land uses;
    - Environmental conditions: soils, hydrology, disturbance patterns, contaminants, predation, invasive species;
    - Specific life history needs;
- The likelihood that a potential species of concern would have a positive reaction to management strategies.

Where possible, management on the refuge restores or mimics natural ecosystem processes or functions and thereby maintains biological diversity, integrity, and environmental health. Given the continually changing environmental conditions and landscape patterns of the past and present (e.g., rapid development, hydrologic modifications, climate change, sea level rise), relying on natural processes is not always feasible nor always the best management strategy for conserving wildlife resources. Uncertainty about the future requires that the refuge manage within a natural range of variability, rather than emulating an arbitrary point in time. This maintains mechanisms that allow species, genetic strains, and natural communities to evolve with changing conditions, rather than necessarily trying to maintain stability.

Based on the criteria listed above and the habitat types identified on the refuge, we developed a table of species of concern with their associated habitat types (Table 3). This table also summarizes the habitat structure required by each resource of concern.

Table 3. Habitat type, resources of concern, and habitat structure on Bayou Sauvage NWR

Habitat Type	Resource of Concern	Habitat Structure
Intermediate/ Brackish Emergent Wetlands	**Dabbling Ducks**	A mixture of emergent marsh and open water ponds (50:50 ratio). A variety of seed and tuber producing emergent vegetation, such as bulrushes (*Schoenoplectus spp*.), sprangletops (*Leptochloa spp.*), sedges (*Cyperus spp*.), panicums (*Panicum spp*.), and cord grasses (*Spartina spp*.) A combination of annuals and perennials. Water depth 15 – 30 cm. Feed on moist-soil seeds, tubers, macroinvertebrates, and leafy vegetation (Fredrickson and Taylor 1982; Chabreck et al. 1989).
	Wood Duck	
	Green-winged Teal	
	Mottled Duck*	
	Mallard	
	Northern Pintail	
	Blue-winged Teal	
	Northern Shoveler	
	Gadwall	
	American Wigeon	
	Shorebirds	Shallowly flooded (<10 cm) and moist mudflats with <25% vegetative cover. Primary diet consists of aquatic macroinvertebrates, but also feed on moist-soil seeds (Helmers 1992; Skagen and Omen 1996).
	Black-bellied Plover	
	American Golden-Plover	
	Semipalmated Plover	
	Killdeer*	
	Black-necked Stilt*	
	American Avocet	
	Greater Yellowlegs	
	Lesser Yellowlegs	
	Willet	
	Solitary Sandpiper	
	Spotted Sandpiper	
	Upland Sandpiper	
	Ruddy Turnstone	
	Marbled Godwit	
	Sanderling	
	Baird's Sandpiper	
	Semipalmated Sandpiper	
	Western Sandpiper	
	Least Sandpiper	
	White-rumped Sandpiper	
	Pectoral Sandpiper	

Habitat Type	Resource of Concern	Habitat Structure
	Dunlin	
	Stilt Sandpiper	
	Short-billed Dowitcher	
	Long-billed Dowitcher	
	Wilson's Snipe	
	American Woodcock	
	Wilson's Phalarope	
	Secretive Marsh Birds (See Table 6 for a list of species)	Tall, dense emergent vegetation, such as cattail (*Typha spp.*), bur reed (*Sparganium spp.*), and bulrush (*Schoenoplectus spp.*), with water depth < 4 in. and a vegetation - open water ratio of 70:30. Inhabit wetlands <2.5 to 62.5 acres, but is more abundant in larger wetlands. Feed on insects, amphibians, small fish, mammals, and crayfish in vegetation fringes and shorelines (Gibbs et al. 1992; Lor 2000).
Forested Wetlands, Scrub-shrub	**Neotropical Migrant Songbirds** (See Table 7 for list of species)	Structurally diverse stands of hardwood and maritime forests with diverse structure and species composition of understory. Maximized edge effect (Petit 2000). Scrub-shrub habitat preferred as stopover habitat by vireos and certain warbler species. See Table 7.

DABBLING DUCKS

Dabbling ducks are selected as a priority resource of concern, because the resource is identified specifically within the refuge purpose, supports the Refuge System mission, supports the Migratory Bird Treaty Act, are a signature group of species that use coastal wetland habitats and are an appropriate focal species to reflect the condition of coastal Louisiana wetlands, also identified within the refuge purpose. The refuge commonly attracts 9 species of dabbling ducks during the winter. Mottled ducks and wood ducks, both year-round residents, also winter on the refuge. Refer to Appendix C for a complete listing of waterfowl known to occur on the refuge, and to the Bayou Sauvage NWR bird list (U.S. Fish and Wildlife Service 1995) for a ranking of seasonal appearance and abundance.

Because of historic and ongoing habitat losses due to agricultural development, urban and suburban development, oil and gas exploration and extraction, climate change, and other factors, suitable habitat for wintering waterfowl in North America has decreased over the past two centuries, leading to a decrease in waterfowl populations (Batt et al. 1992). When large, unbroken expanses of wetlands and coastal prairies were available for use by waterfowl, the entire system was more resilient in the face of natural disturbances such as fire, drought, and tropical storms. In the current, anthropogenically

modified landscape, habitat loss, habitat fragmentation, the introduction of exotic plant and animal species, and disruption of natural hydrologic and pyric processes mean that remaining habitat, in order to function in the larger context of the continent-wide ecosystem, must be actively managed. Small fragments of habitat are less resilient to disturbances, and without management of vegetation, hydrology, fire, and animal populations, will change over time so that they no longer serve as high-quality habitat for waterfowl or other desirable species.

SHOREBIRDS

Shorebirds, like dabbling ducks, are identified in the original refuge purpose as being a focus for Bayou Sauvage NWR. The refuge provides important habitat for 9 groups of shorebirds, comprising 28 species (Table 5). The refuge is strategically located for migratory shorebird species which winter on the Gulf coast, and also provides high-quality habitat for year-round resident species and those which breed on the refuge. Because of the urban character of most of the southern shore of Lake Pontchartrain, the refuge protects one of the last large blocks of this type of habitat in the area.

SECRETIVE MARSH BIRDS

A suite of marsh birds, including 8 species in the family Rallidae, as well as pied-billed grebe, eared grebe, horned grebe, and least bittern (Table 5), depend on the marsh habitats on Bayou Sauvage NWR and are a resource for which the refuge was created in 1990. These birds were selected as a resource of concern, because they serve as focal resources for the marsh habitat which composes most of the refuge, and their conservation is a priority for refuge managers. Marsh birds have ecological value as important elements of natural systems and perform valuable functions benefitting the natural balance in ecosystems as well as providing many benefits to humans (Kushlan et al. 2002). Protecting habitat for these birds will improve biological integrity, diversity, and ecological health of the entire system.

NEOTROPICAL MIGRANTORY SONGBIRDS

One of the original purposes for which Bayou Sauvage NWR was created in 1990 includes neotropical migratory songbirds. Before Hurricane Katrina, the refuge provided 2,000-3,000 acres of high-quality forest habitat which was used as stopover habitat by many species of trans-Gulf migratory birds. Because stopover habitat is so important, and because it is limited in the vicinity of Bayou Sauvage NWR, restoring this habitat on the refuge is a high priority for refuge managers.

SPECIES WITH COMPLEMENTARY HABITAT REQUIREMENTS

While habitat objectives and strategies will be established based primarily on the habitat needs of the above identified resources of concern, refuges can and should be managed through a strategic habitat management approach that includes other species which represent ecosystem complexity and diversity and extends to the broader landscape in which the refuge lies. The following species (Table 4) have habitat needs that are largely complementary to those of the resources of concern and are expected to benefit from management designed primarily to meet the needs of the resources of concern. On Bayou Sauvage NWR, these include the following groups: diving ducks, wading birds, and alligators.

Table 4. Wildlife species on Bayou Sauvage NWR which have complementary habitat requirements to those of the resources of concern and which will likely benefit from management actions listed in this plan, and the habitats they use on this refuge

Common Name	Intermediate Marsh	Brackish Marsh	Coastal Hardwoods	Open Water
DIVING DUCKS				
Canvasback	x	x		X
Redhead				X
Ring-necked Duck	x	x		X
Greater Scaup				X
Lesser Scaup				X
Oldsquaw				X
Black Scoter				X
Surf Scoter				X
White-winged Scoter				X
Common Goldeneye				X
Bufflehead	x	x		X
Hooded Merganser	x	x		X
Red-breasted Merganser				X
Ruddy Duck				X
WADING BIRDS				
American Bittern	x	x	x	
Great Blue Heron	x	x	x	
Great Egret	x	x	x	
Snowy Egret	x	x	x	
Little Blue Heron	x	x	x	
Tricolored Heron	x	x	x	
Reddish Egret	x	x	x	
Cattle Egret	x	x	x	

Common Name	Intermediate Marsh	Brackish Marsh	Coastal Hardwoods	Open Water
Green Heron	x	x	x	
Black-crowned Night-Heron	x	x	x	
Yellow-crowned Night-Heron	x	x	x	
White Ibis	x	x	x	
Glossy Ibis	x	x	x	
White-faced Ibis	x	x	x	
Roseate Spoonbill	x	x	x	
Wood Stork	x	x	x	
ALLIGATORS				
American Alligator	x	x		

HABITAT REQUIREMENTS OF RESOURCES OF CONCERN

DABBLING DUCKS

Wintering Dabbling Ducks

Most North American waterfowl species satisfy their annual cyclic habitat needs through long-distance migration. Habitat requirements vary with the breeding cycle, and habitats all along the flyways are critical links in a chain which sustains waterfowl populations. Strategic conservation of habitat, including planning, protection, and management, is the primary way that humans can ensure healthy populations of waterfowl (or any wildlife) (Reinecke et al. 1989).

During winter, dabbling ducks prefer shallow wetland habitat that is approximately 50 percent vegetation and 50 percent open water, dispersed in a mosaic pattern with the largest edge effect possible. In coastal Louisiana, wintering waterfowl forage and rest in marshes and moist-soil habitats. Both marshes and moist-soil habitats (either natural early successional mud flats or managed moist-soil units) are rich in edible plant material (grass and sedge seeds, roots, tubers, etc.) and aquatic invertebrates (Kaminski et al. 2003; Heitmeyer 1988; Heitmeyer 2006). Mallards, gadwall, teal, American wigeon, shovelers, and geese all utilize marsh and moist-soil areas as preferred habitats (Fredrickson and Heitmeyer 1988). Moist soil areas and marsh serve as habitat for loafing, pair bonding, and feeding, and provide refuge from disturbance and cold conditions (Reinecke et al. 1989).

Protecting waterfowl from disturbance caused by humans and other predators as well as noise from boats and guns is crucial for good wintering habitat. D ucks and geese have significant energetic and nutritional requirements to support moults and other biological processes and to maintain them through cold weather periods. Disturbance-free habitat enables them to build energy reserves for spring migration and reproduction (Reinecke et al. 1989; Strickland et al. 2009). If waterfowl are

disturbed on wintering habitat, it can interfere with feeding and resting and cause the ducks not to gain sufficient weight to sustain them through the year (Henry 1980; Heitmeyer and Raveling 1988; Kahl 1991). In a study in Louisiana, even increased foraging time by gadwalls was insufficient to overcome the effects of disturbance (Paulus 1984).

Mottled Ducks

Mottled ducks are dabbling ducks closely related to mallards. They have very similar wintering habitat requirements to other members of their genus. However, unlike most North American *Anas* species, they are year-round residents of the Gulf coast. They therefore require habitat for breeding, feeding, loafing, and other activities during the spring, summer, and fall, as well as during the winter. Mottled ducks generally prefer fresh to brackish marsh for feeding and loafing, although they will use rice fields and rarely flooded prairie sites as well (Rorabaugh and Zwank 1983). They primarily consume plant material as adults, grazing in shallow water for seeds or in deeper water on submerged aquatic plants (Paulus 1984), but consume more animal material as ducklings when additional protein is required (Rorabaugh and Zwank 1983). Over the year, these birds use a succession of habitat types for different activities. During pair bonding in early winter, mottled ducks preferentially use small ponds within the coastal marsh for attracting mates and pairing (Haukos et al. 2010). Then, hens select nesting habitat which has quite different characteristics, and after hatching, they seek out brood habitat with yet another set of characteristics (Rorabaugh and Zwank 1983). Post-breeding habitat differs from all of the habitats used during the breeding season. Although all of these habitat types are found within healthy coastal marsh, it is important for managers to understand how specific habitat requirements change over the year. Each of these four habitat types will be discussed below.

Post-breeding/wintering habitat

Mottled ducks primarily feed (as adults) on plant materials in shallow (≤30 cm/1 ft.) water. They spend most of their time in or near emergent, graminoid marsh habitat. During the post-breeding molt, when they are flightless for a month, they prefer larger bodies of water with shallow beds of submerged aquatic vegetation and escape cover on the margins (Rorabaugh and Zwank 1983). Salinities in these habitats can vary from fresh to brackish or saline.

Pairing pond habitat

Sometime in late fall or early winter, pair bonding begins for this species. Drakes occupy and defend small (0.02-0.15 ha/0.05-0.4 ac, ~1 m/3 ft. deep) ponds surrounded by marsh habitat (Haukos et al. 2010), and by December, 90 percent of them are paired (Paulus 1984). In a recent study in southeast Texas, mottled ducks used ponds with salinities ranging from fresh to saline; however, they preferentially selected shallow, fresh ponds (≤ 2 ppt salinity) and ones that were surrounded by marsh vegetation that had been grazed recently. They avoided ponds surrounded by recently burned marsh vegetation (Haukos et al. 2010).

Nesting habitat

Mottled ducks begin nesting in February, and nesting continues through August (Rorabaugh and Zwank 1983; Walters 2000). They prefer a high land/water ratio for nesting habitat, and prefer prairie vegetation over marsh or woody cover (Walters 2000). Nests are often found against clumps of grass or small shrubs within 150 m (~500 ft.) of water. Nesting mottled ducks will generally avoid areas which are wet or which have dense shrubs or trees (Rorabaugh and Zwank 1983).

Brood habitat

Hens will select brood habitat which, unlike breeding habitat, has a low land/water ratio, but which has abundant edge and cover for ducklings. Ducklings are less efficient feeders than adults, so hens will preferentially bring broods to areas of abundant food supply (Afton and Paulus 1992) and may travel several kilometers (1 km = 0.6 miles) from the nest to reach favorable brood-rearing habitat (Paulus 1984). Young ducklings (<4 weeks) require a high proportion of their diet to be of animal origin, chiefly small fish, mollusks, insects, and amphipods (Rorabaugh and Zwank 1983).

Wood Ducks

The wood duck inhabits quiet inland waters near woodland, such as wooded swamps, flooded forest, greentree reservoirs, ponds, marshes, and streams; it winters on both freshwater and brackish marshes, ponds, streams, and estuaries. Wood ducks spend most of their life cycle in and around forested wetlands (U.S. Fish and Wildlife Service 2001). They nest in tree cavities within 1 km (2/3 mi) (preferably 500 m/~1600 ft. or less) of water; longer distances are associated with lower brood survival (U.S. Fish and Wildlife Service 2001). Good natural breeding habitat has approximately one usable cavity (1000-5000 cu. in.) per 5 acres (Bellrose et al. 1964). Flooded wood duck habitat is ideally shallow with 50-75 percent cover provided by shrubs or emergent vegetation (Dugger and Fredrickson 2007; U.S. Fish and Wildlife Service 2001). Nest boxes are readily used, and single, hidden, well-spaced boxes are best (Haramis and Thompson 1985) (Hepp and Bellrose 1995). Wood ducks forage mostly in flooded timber, and will only use agricultural habitat if forest is not available. Since wood ducks rarely dive or feed from the bottom, they require shallow (< 8 inches) water for feeding (Dugger and Fredrickson 2007).

Wood ducks begin nesting as early as late January on the Gulf coast, and the incubation period is 30 days or less (Dugger and Fredrickson 2007). They are omnivorous, but their proportion of animal and plant food sources changes through the year reflecting availability of food and nutritional requirements of breeding, moult, and wintering. During the breeding season, foraging habitat must provide energy and protein for the hen during egg-laying and for the developing ducklings. Hens eat mainly (80 percent) animal food sources during egg-laying, concentrating on invertebrates that are available on the surface of the water and on riparian areas. Drakes increase their intake of animal sources during the spring as well; invertebrates compose up to 1/3 of their diet during this time. During incubation, hens shift to high-energy seeds to meet the metabolic requirements of incubation. Ducklings consume mostly invertebrates and small fish until they are 6 weeks old, and then shift to mostly plant sources as they mature (U.S. Geological Survey 2006). During the winter, diet for both sexes shifts to nearly 100 percent plant sources, and acorns may account for up to 75 percent of the total intake.

Bayou Sauvage NWR currently provides 1,964 acres of coastal hardwood habitat, all of which is within 500 miles of marsh and/or shrub vegetation suitable for brood habitat. Much of this habitat is recovering from heavy disturbance from Hurricane Katrina, and suitable nest cavities are lacking. The refuge currently maintains 25 nest boxes to alleviate the shortage of natural cavities.

SHOREBIRDS

Shorebirds have adapted to exploit various habitat types within coastal and interior wetlands. During migration, shorebirds primarily use shallowly flooded coastal or freshwater habitats, with water depths of <10 cm (Helmers 1992). (Elliott and McKnight 2000) defined non-maritime shorebird habitat as "those occurring inland from the upland grasslands on bay sides of barrier islands and the mainland, and from the back beach inland. These habitats include coastal marsh (saline to fresh), prairie, agricultural lands (rice, crawfish), and inland ponds (including waterfowl impoundments) and depressions." Sediment splays in the Mississippi River delta are particularly heavily used by shorebirds during the winter (Elliott and McKnight 2000), with high numbers of dunlin, western sandpiper, and long-billed dowitcher. Shorebirds also forage in impoundments which are managed primarily for waterfowl. Freshly dewatered mudflats are rich in invertebrate prey, which sustains migrating and wintering shorebirds, while some species use the areas when they are flooded, depending on foraging guilds. Table 5 summarizes shorebird foraging guilds and habitats used by shorebirds. Within impoundments, Bayou Sauvage NWR provides extensive acreage of shorebird habitat, with water levels within -0.5 and 0.5 ft. of marsh sediment elevation. In addition, mudflats of various sizes and vegetation coverage may be available in Units 1, 7, 8, and 9 (outside the levee system), depending on tides, wind, and precipitation.

Table 5. Shorebird foraging guilds and habitat types on Bayou Sauvage NWR (from Helmers 1992)

Shorebird Group	Foraging Guild*	Habitat Type		
			Vegetation Structure	
		Substrate	Height	Density
Plover	terr/aqua gleaners	dry/saturated	none/short	sparse
Curlew	terr/aqua gleaners/probers	dry/saturated	short/medium	moderate/dense
Sandpiper	aqua/terr gleaners/probers	flooded/saturated	none/short	sparse
Godwit	aqua probers	flooded	short/medium	sparse/moderate
Yellowlegs	aqua gleaners	flooded	short/medium	sparse/moderate
Turnstone	terr/aqua gleaners/probers	rocky intertidal	none/short	sparse
Avocet/Stilt	aqua gleaners/sweepers	flooded	none/short	sparse

Shorebird Group	Foraging Guild*	Habitat Type		
			Vegetation Structure	
		Substrate	Height	Density
Phalarope	aqua gleaners	flooded	none/short	sparse/moderate

SECRETIVE MARSH BIRDS

As with many other groups of birds, the variables that control habitat selection and quality are many and complex for secretive marsh birds. At small scales, food availability, cover, nest material, protection from predators and weather, presence of open water, water depth, and type, height and density of vegetation, all influence habitat selection and use by these birds (Riffell et al. 2003; Osnas 2003; Lor and Malecki 2006; Johnson and Dinsmore 1986). On landscape scales, the area and distribution of suitable habitat patches is an important determinant in use by certain marsh birds, while others appear not to be affected by these variables (Brown and Dinsmore 1986; Benoit and Askins 2002; Fairbairn and Dinsmore 2001). A general understanding of these variables and how they influence habitat quality and avian species richness on the refuge is important for management decisions. Two habitat requirements are shared by most or all of the species which use Bayou Sauvage NWR: the presence of emergent marsh vegetation, mostly graminoid, and the presence of open water in various proportions to the marsh cover. Specific requirements of the eleven species of secretive marsh birds which breed or winter on Bayou Sauvage NWR are presented in Table 6.

Bayou Sauvage NWR can provide approximately 8,676 acres of brackish marsh, and 5,703 acres of intermediate marsh, as well as 7,044 acres of open water habitat used by secretive marsh birds and their allies.

Table 6. Specific habitat requirements of eleven secretive marsh bird species which breed or winter on Bayou Sauvage NWR

SPECIES	Emergent graminoid marsh	Preferred or associated plant species (Gulf Coast portion of range)	Open Water	Salinity	Water Depth	Other requirements or preferences	Large Scale Requirements
King Rail* (Poole et al. 2005)	yes	*Typha* spp., *Schoenoplectus olneyi, Spartina cynosuroides, Zizaniopsis miliacea, Panicum hemitomon, Cladium jamaicense, Echinochloa* spp., *Polygonum* spp.		Fresh to brackish		High marsh with sparse woody vegetation	
Clapper Rail* (Eddleman and Conway 1998)	yes	*Spartina alterniflora, S. patens, Salicornia* spp., *Juncus roemerianus, Avicennia* spp.,	nest within 15 m of open water	5.6-7.0 ppt	shallow	Low marsh; Scattered shrubs; 25% of marsh within 15m of a shoreline	
Yellow Rail (Bookhout 1995)	yes	Spartina spp.				Drier portions of marsh	

SPECIES	Emergent graminoid marsh	Preferred or associated plant species (Gulf Coast portion of range)	Open Water	Salinity	Water Depth	Other requirements or preferences	Large Scale Requirements
Virginia Rail (Conway 1995)	yes	*Typha spp., Schoenoplectus spp.,*	Uses open water as escape cover (swims underwater)	Fresh to salt marsh	Mudflat to shallow water	Needs high invertebrate abundance in substrate	
Sora (Melvin and Gibbs 1996)	Yes			Freshwater, brackish, saline (Eddleman et al. 1988)	May select areas of shallower water than Virginia Rails	Shallow water and emergent vegetation	

SPECIES	Emergent graminoid marsh	Preferred or associated plant species (Gulf Coast portion of range)	Open Water	Salinity	Water Depth	Other requirements or preferences	Large Scale Requirements
Common Moorhen* (Bannor and Kiviat 2002)	Yes	*Panicum hemitomon, Juncus* spp., *Pontederia cordata, Peltandra virginica, Sagittaria lancifolia, Nuphar* spp., *Nymphaea* spp., *Nelumbo lutea*, *Ceratophyllum demersum, Potamogeton* spp., *Vallisneria americana, Hydrilla verticillata; Spartina spartinae in wintering habitat*	Yes, mixed with emergent marsh;	Fresh to slightly brackish		Robust graminoid vegetation, tidal marsh; floating and submerged aquatic vegetation is preferred; can use wide variety of habitats	

SPECIES	Emergent graminoid marsh	Preferred or associated plant species (Gulf Coast portion of range)	Open Water	Salinity	Water Depth	Other requirements or preferences	Large Scale Requirements
Purple Gallinule* (West and Hess 2002)	yes	*Brasenia schreberi, Nelumbo lutea, Nuphar lutea, Nymphaea odorata, Pontederia cordata, Sagittaria* spp., Typha spp., *Panicum hemitomon, Schoenoplectus* spp., *Zizaniopsis miliacea, Juncus* spp., *Lemna* spp., *Eichhornia crassipes, Potamogeton* spp., *Ceratophyllum demersum, Hydrilla verticillata, Cephalanthus occidentalis.*	Prefers <25% open water	0-5.0 ppt	deep: 0.25-1.0m	Walks on floating or emergent vegetation to feed on invertebrates and flowers	

SPECIES	Emergent graminoid marsh	Preferred or associated plant species (Gulf Coast portion of range)	Open Water	Salinity	Water Depth	Other requirements or preferences	Large Scale Requirements
American Coot (Brisbin Jr., and Mowbray 2002)	Yes		Yes; uses bays and ponds, especially in winter	Fresh to brackish	Deep water often used		
Horned Grebe (Stedman 2000)			Moderate to large fresh to saltwater	0-35 ppt.			
Eared Grebe (Cullen et al. 1999)	yes	Rare on Gulf Coast	Saltwater			Most Eared Grebes winter in Baja California	
Pied-billed Grebe* (Muller and Storer 1999)	marsh nest requires ≥10 cm^2 of stem basal area per m^2 of marsh		Breeds on ponds >0.2ha	Fresh to brackish	>.25m	Nest on floating platform among tall emergent vegetation on in open water	Area-dependent breeder (Naugle et al. 2001); Nests much more frequently in marsh habitat patches ≥5ha (Brown and Dinsmore 1986)

SPECIES	Emergent graminoid marsh	Preferred or associated plant species (Gulf Coast portion of range)	Open Water	Salinity	Water Depth	Other requirements or preferences	Large Scale Requirements
Least Bittern*		*Typha* spp., *Carex* spp., *Schoenoplectus* spp., *Sagittaria* spp., *Mariscus* spp.	Yes, mixed with marsh and woody vegetation	Fresh to brackish	≤0.5m	Clumps of woody vegetation	Nests much more frequently in marsh habitat patches ≥5ha (Brown and Dinsmore 1986)

NEOTROPICAL MIGRATORY SONGBIRDS

Neotropical migratory songbirds require woodland stopover habitat during the fall and spring migrations to rest and rebuild energy reserves for the remainder of their migration and/or for breeding (Kuenzi et al. 1991; Yong and Moore 1997; Yong et al. 1998). Although the proportion of the life cycle spent in this type of habitat is small, stopover habitat represents a critical link in the chain of habitats required for migratory bird species to survive (Moore et al. 1990; Moore et al. 1992). As coastal development increases, the quantity and quality of this type of habitat becomes rarer, and this habitat loss may impact migratory bird survival and breeding fitness (McCann et al. 1993). Gulf habitats lying just north of the coastal marshes are especially important as stopover sites forming the last stop before, or first stop following, the demanding trans-Gulf flight (Yaukey 2010). Indeed, (Yaukey 2010) suggested the volume of bird movement that occurs on Bayou Sauvage NWR is one of the major migratory songbird concentration locations in the Western Hemisphere. Therefore, an important element of conservation of these species is the maintenance and restoration of coastal woodland habitat along migratory routes (Moore et al. 1992).

A list of neotropical migratory songbirds which are known from Bayou Sauvage NWR during the spring and fall migration periods is presented in Table 7. While breeding and wintering habitat requirements for these species vary widely, most of them are able to take advantage of forest or woodland habitat for migration stopover (Moore et al. 1992; Packett and Dunning Jr., 2009). (Moore et al. 1992) gives three habitat-related factors which determine habitat quality for migratory bird stopover on the Gulf coast: foraging opportunities, competitive pressure, and shelter from predators and adverse weather. However, they state that for energy-depleted spring migratory birds, the most important aspect of stopover habitat is probably the availability of food resources, followed closely by cover from predation. Working in Indiana, (Packett and Dunning Jr., 2009) found that small, early successional patches of forest in an agricultural landscape were preferentially selected by fall-migrating songbirds, presumably because of the abundance of early successional fruit-bearing vegetation. Spring migratory birds in their study were less selective, but tended to favor native vegetation and patches with vernal pools, which may be sources of emerging insect prey. (Moore et al. 1990) found that trans-Gulf migratory birds stopping over on Horn Island, Mississippi, favored scrub-shrub, slash pine forest, and “relic dune” (low productivity sparse shrubs with emergent pines and live oaks) habitat types over primary dune (open habitat) and marsh/meadow. (Kuenzi et al. 1991), working on East Ship Island, Mississippi, found that most trans-Gulf migratory songbirds using relic dune habitat tended to lose weight and to leave for better habitat soon after arrival. Likewise, (Panjabi 1999) attributed the greatest abundance of migrants and migrant species occurring in mixed woodlands of the Mississippi Delta to structural diversity and diversity of vegetation types. In general, it is clear that floristically and structurally diverse, productive woodlands comprising mostly native species will provide high-quality stopover habitat for most spring and fall neotropical migratory songbirds.

(Moore et al. 1992) gave the following management recommendations for providing high-quality stopover habitat for migrating songbirds:

A. WITHIN-HABITAT SCALE

1. Migratory birds use en-route habitat for different reasons: Rest, fat deposition, molt, hydration, safety from predators.

2. A variety of foods, including insects and fruit, is important both spring and fall migration. Fruit facilitates fat deposition and provides a rapid (short-term) solution to nutrient deficiencies which result from prolonged activity (i.e., migratory flight).

3. Management practices that reduce food (insect, fruit) abundance should be scrutinized (e.g., pesticide application).

A. LANDSCAPE SCALE

1. Given diversity of migratory species, a diverse array (mosaic) of habitats is preferred.

2. Floristic and structural diversity is desired (e.g., mixed forest and scrub-shrub habitats "attract" more individuals and are characterized by greater species richness).

3. Maintain mixed communities in urban and agricultural landscapes as well as managed forests. For example, city parks can host dozens of species and many individuals during migration.

B. GEOGRAPHIC SCALE

1. Because migratory pathways are only loosely defined and influenced by seasonal weather patterns, suitable stopover habitat should be managed across a breadth of possible migratory pathways. A matrix of widely distributed habitats may be more effective than a small number of large habitat areas.

2. The continental-wide pattern of migration concentrates migratory birds in relation to ecological barriers. Crossing barriers can place extreme energetic demands on these birds.

3. Protection and management of habitats used by migratory birds in relation to ecological barriers should be a priority, especially along the northern coast of the Gulf of Mexico (spring and fall), the Atlantic Coast (fall), and riparian habitats in the southwestern United States (spring and fall).

4. Conservation is exacerbated by population growth and land conversion taking place in both coastal and riparian areas.

5. Migratory birds and their habitats should be included as significant coastal resources in state coastal zone management plans.

Table 7. Neotropical migratory songbird species known to use Bayou Sauvage NWR during spring and/or fall migration, with selected specific information about habitat preference

SONGBIRDS (PASSERIFORMES, SUBORDER OSCINES)	OCCURRENCE ON BAYOU SAUVAGE NWR**		SPECIFIC INFORMATION ON HABITAT SELECTION DURING MIGRATION
Family, Common Name	**Spring**	**Fall**	
Vireonidae			
White-eyed Vireo*‡	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi (Moore et al. 1990)
Blue-headed Vireo	u	u	
Yellow-throated Vireo*‡	u	u	
Warbling Vireo	-	r	
Philadelphia Vireo*	u	u	
Red-eyed Vireo*	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi (Moore et al. 1990)
Bombycillidae			
Cedar Waxwing	c	r	
Hirundinidae			
Purple Martin*	c	c	
Tree Swallow	c	c	
Northern Rough-winged Swallow	u	u	
Bank Swallow	u	u	
Cliff Swallow	u	u	
Barn Swallow*	C	C	
Regulidae			
Ruby-crowned Kinglet	c	c	

SONGBIRDS (PASSERIFORMES, SUBORDER OSCINES)	OCCURRENCE ON BAYOU SAUVAGE NWR**		SPECIFIC INFORMATION ON HABITAT SELECTION DURING MIGRATION
Family, Common Name	**Spring**	**Fall**	
Troglodytidae			
House Wren	c	c	
Sedge Wren	c	c	
Marsh Wren*	c	c	
Sylviidae			
Blue-gray Gnatcatcher*	c	c	
Certhiidae			
Brown Creeper	r	r	
Mimidae			
Gray Catbird	c	c	
Turdidae			
Veery	u	u	
Gray-cheeked Thrush	u	u	Gained weight in relic dune habitat (Kuenzi et al. 1991).
Swainson's Thrush	c	c	
Hermit Thrush	u	u	
Wood Thrush‡	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi (Moore et al. 1990)
American Robin	C	C	
Motacillidae			
American Pipit	u	u	
Fringillidae			
Pine Siskin	e	e	

SONGBIRDS (PASSERIFORMES, SUBORDER OSCINES)	OCCURRENCE ON BAYOU SAUVAGE NWR**		SPECIFIC INFORMATION ON HABITAT SELECTION DURING MIGRATION
Family, Common Name	**Spring**	**Fall**	
American Goldfinch	c	c	
Parulidae			
Blue-winged Warbler‡	u	u	Reported to use forest edge and dense shrub habitat during migration (Gill et al. 2001).
Golden-winged Warbler‡	u	u	Forest edge and regeneration (Confer et al. 2011)
Tennessee Warbler	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi (Moore et al. 1990)
Nashville Warbler	-	r	
Orange-crowned Warbler	c	c	
Northern Parula*	c	c	
Yellow Warbler	u	c	
Chestnut-sided Warbler	u	u	
Magnolia Warbler	c	c	
Yellow-rumped Warbler	a	a	
Black-throated Green Warbler	u	c	
Blackburnian Warbler	u	u	
Yellow-throated Warbler*‡	u	u	Prefers tall trees during migration (McKay and Hall 2012).
Prairie Warbler‡	-	u	
Palm Warbler	r	u	
Bay-breasted Warbler	u	u	
Blackpoll Warbler	r	-	Gained weight in relic dune habitat (Kuenzi et al. 1991).

SONGBIRDS (PASSERIFORMES, SUBORDER OSCINES)	OCCURRENCE ON BAYOU SAUVAGE NWR**		SPECIFIC INFORMATION ON HABITAT SELECTION DURING MIGRATION
Family, Common Name	**Spring**	**Fall**	
Cerulean Warbler‡	u	u	
Black-and-white Warbler	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi (Moore et al. 1990).
American Redstart	c	c	
Prothonotary Warbler*‡	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi(Moore et al. 1990).
Worm-eating Warbler‡	u	u	
Swainson's Warbler‡	r	-	
Ovenbird	u	u	
Northern Waterthrush	u	u	
Louisiana Waterthrush‡	r	r	As during the breeding season, uses habitat close to water (Mattsson et al. 2009).
Kentucky Warbler‡	u	u	
Mourning Warbler	o	o	
Common Yellowthroat*	c	c	
Hooded Warbler*‡	c	c	Strong preference (>50% of detections) for scrub-shrub habitat, spring migration, Horn Island, Mississippi (Moore et al. 1990).
Wilson's Warbler	r	u	
Canada Warbler	o	u	
Yellow-breasted Chat*	u	u	
Icteridae			
Bobolink	r	-	
Red-winged Blackbird*	a	a	

SONGBIRDS (PASSERIFORMES, SUBORDER OSCINES)	OCCURRENCE ON BAYOU SAUVAGE NWR**		SPECIFIC INFORMATION ON HABITAT SELECTION DURING MIGRATION
Family, Common Name	**Spring**	**Fall**	
Bronzed Cowbird	o	-	
Brown-headed Cowbird*	c	c	
Orchard Oriole*	c	c	Gained weight in relic dune habitat (Kuenzi et al. 1991).
Northern (Baltimore) Oriole	u	u	
Emberizidae			
Chipping Sparrow	u	u	
Clay-colored Sparrow	-	r	
Vesper Sparrow	r	r	
Savannah Sparrow	c	c	
Grasshopper Sparrow	-	o	
Lincoln's Sparrow	r	r	
Swamp Sparrow	a	a	
White-crowned Sparrow	r	r	
Dark-eyed Junco	r	r	
Thraupidae			
Summer Tanager	c	c	
Scarlet Tanager	u	u	
Cardinalidae			
Dickcissel	o	o	Requires large areas of herbaceous vegetation, either prairie or marsh, with abundant seed production, for feeding habitat during migration (Temple 2002)
Rose-breasted Grosbeak	c	c	

SONGBIRDS (PASSERIFORMES, SUBORDER OSCINES)	OCCURRENCE ON BAYOU SAUVAGE NWR**		SPECIFIC INFORMATION ON HABITAT SELECTION DURING MIGRATION
Family, Common Name	**Spring**	**Fall**	
Blue Grosbeak	c	c	
Indigo Bunting‡	c	c	Generalist, but feeds on grass seeds in open areas during migration (Payne 2006).
Painted Bunting*‡	c	c	Uses open and shrubby habitats in migration (Lowther et al. 1999).
Tyrannidae			
Eastern Kingbird*	c	c	

**Breeds on refuge*
***a=abundant; c=common; u=uncommon; r=rare; e=erratic; o=occasional.*
‡Species of Continental Importance (Rich et al., 2004)

Bayou Sauvage NWR has the capacity to provide 1,965 acres of forested habitat and 1,352 acres of scrub-shrub habitat suitable for migratory stopover by neotropical migratory songbirds. Most of the forested habitat is in need of restoration and intensive management to restore its function, having been severely damaged by hurricane winds and saltwater intrusion from Hurricane Katrina.

RECONCILING CONFLICTING HABITAT NEEDS

No significant conflicting habitat needs among the refuge's resources of concern were identified.

VI. Habitat Management Goals and Objectives

Goals and objectives are defined for Bayou Sauvage NWR in the refuge's comprehensive conservation plan (U.S. Fish and Wildlife Service 2009a). The following habitat management goals and objectives are tiered to those in the comprehensive conservation plan (CCP) and serve to refine the general direction provided therein. Goals are general statements outlining desired future habitat conditions. They provide a framework for management decision-making and serve to express general principles in accordance with the refuge's purpose. Objectives are more specific statements of desired future condition which give enough quantitative information and detail so that strategies can be devised to achieve them and monitoring protocols can be designed to test whether they have been achieved.

Habitat Management Goal: Restore and maintain intermediate and brackish marsh systems, scrub-shrub habitat, and maritime hardwood forests to ensure healthy and viable ecological communities, with emphasis on migratory birds and threatened and endangered species.

Rationale: Historically, seasonal flooding from the Mississippi River recharged the refuge's aquatic systems and created a broad range of dynamic habitats that supported diverse fish and wildlife resources. The natural hydrology of this area was changed with the construction of levees, installed to protect New Orleans from periodic river flooding and, later, hurricane protection levees to protect against major storm surges. The loss of this annual flooding regimen and disruption of tidal flows detrimentally impacted the wetland habitats and wetland-dependent species.

The position of Bayou Sauvage NWR as an oasis in the midst of urban development makes it an important resting and feeding area to trans-Gulf migratory songbirds, as well as waterfowl and shorebirds. Moist-soil management began in the 1990s, and waterfowl numbers increased during this period. Consistently since 2000, numbers of waterfowl have decreased not only on the refuge, but in the Lake Pontchartrain basin area in general. Christmas bird counts also show lower numbers of other waterbirds since 2000. The decrease is probably a result of reduced moist-soil plant production caused by droughts and hurricanes. Not only is emergent vegetation production lower, but certain species of submerged aquatic vegetation were also lost due to higher salinity levels in the water following the Hurricane Katrina storm surge.

HABITAT MANAGEMENT OBJECTIVE 1: RESIDENT DABBLING DUCK HABITAT

Over the next 15 years, provide sufficient habitat for resident, cavity-nesting dabbling ducks (wood ducks and/or black-bellied whistling-ducks) to support 100 hatchlings per year in Units 3 and 5 by ensuring that a minimum of 25 nest boxes are cleaned and available prior to January of each year.

Rationale: While adequate brood and wintering habitat exists on the refuge for these birds, natural nesting cavities have become scarce. Providing and properly maintaining 25 nest boxes would alleviate this limiting factor to reproduction for these species and maintain healthy populations of wood ducks and black-bellied whistling-ducks until forest restoration goals are reached and natural cavities are again available.

Resources of Concern: Dabbling ducks (cavity-nesting--breeding wood ducks).

CCP Objective 1.3, page 49.

Adaptive Management Monitoring Elements:

Primary Habitat Response Variables	Probable Assessment Methods
▪ Abundance of nest boxes available for use by January of each year	▪ Clean nest boxes and make necessary repairs during December of each year
Primary Wildlife Response Variables	**Probable Assessment Methods**
▪ Documented use of nest boxes by wood ducks and black-bellied whistling-ducks ▪ Number of dump nests	▪ Check nest boxes and record use data twice between January and June of each year

HABITAT MANAGEMENT OBJECTIVE 2: FOREST RESTORATION

Over the next 15 years, restore ridges and highest grounds in Units 2, 3, 4, 5, and 8 to coastal hardwood forest, with live oak, bald cypress, hackberry, green ash, red maple, water oak, and black willow. Specific forest conditions for restored areas include:

- 200 planted trees per acre survival after 5 years will be considered stocked
- Invasive exotic species such as Chinese tallow and chinaberry on restored forest land in Units 2, 3, 4, 5, 6, and 8 will be maintained at <10 seed-bearing stems/acre using best management practices, which include chemical control.

Rationale: Prior to summer 2005, the natural levee ridge was a maritime hardwood forest dominated by live oak and sugarberry. Saltwater intrusion due to major storms and an extended drought over the past 15 to 20 years has continually compromised the integrity of the area to support hardwood communities. This has also allowed invasive plants, such as Chinese tallow, to opportunistically spread along this ridge, making it increasingly difficult for the propagation and restoration of native woody vegetation. Quality stopover sites along the Gulf coast, like Bayou Sauvage NWR, are critical for trans-gulf migrants (Yaukey 2010; Moore et al. 1992). Therefore, management strategies are needed to supplement regeneration of coastal hardwoods necessary to increase the quality of this important stopover site.

Bayou Sauvage NWR has several documented native and nonnative invasive plant species, with Chinese tallow as the primary threat. Invasive and exotic species were a problem prior to the 2005 hurricane season, but have proliferated and thrived in the absence of the native species killed by saltwater intrusion. Invasive species impact the refuge's ability to carry out desired wildlife and habitat management objectives and at times also reduce the range of visitor service activities. Many invasive species are difficult to control without applying chemical treatments. The moist-soil conditions conducive to providing quality habitat for migratory waterfowl management frequently encourages germination of those invasive species. If Bayou Sauvage NWR is to restore habitat ravaged by past natural disasters, a major part of this will consist of controlling invasive plant species, especially Chinese tallow and chinaberry trees.

Resources of Concern: Dabbling ducks (cavity nesting--wood ducks, black-bellied whistling ducks), neotropical migratory songbirds.

CCP Objective 2.3, page 51, 2.6, pages 52 – 53.

Adaptive Management Monitoring Elements:

Primary Habitat Response Variables	Probable Assessment Methods
▪ Hardwood survival (i.e., density within 5 years of reforestation ▪ Presence of an oak and hackberry dominated maritime hardwood forest with canopy closure within 20 years ▪ Exotic plant densities and influence on habitat conditions.	▪ Survival surveys. ▪ Species composition, percent cover, distribution surveys ▪ Chinese tallow surveys to determine influence on desired forest habitat conditions
Primary Wildlife Response Variables	**Probable Assessment Methods**
▪ Abundance and richness of songbirds in reforested areas.	▪ Spring and Fall Surveys

HABITAT MANAGEMENT OBJECTIVE 3: MARSH RESTORATION

Over the next 15 years, opportunistically reestablish and restore up to 7,600 acres of intermediate and brackish marsh communities in Units 1a, 3, and 6 (Appendix F) and other units as funding permits.

Rationale: Marsh loss is the most critical issue affecting habitat management. In the Lake Pontchartrain Basin, more than 66,000 acres (>22 percent) of marsh have converted to open water since 1932. Within Bayou Sauvage NWR, a habitat damage assessment conducted following Hurricane Katrina revealed approximately 658 acres (11 percent) of tidally influenced marsh and 1,089 acres (16 percent) of impounded marsh were converted to open water during the storm. The damage assessment further calculated a 9 percent reduction in carrying capacity for migrating and wintering waterfowl (Ecology and Environment 2007). Therefore, marsh restoration is a significant management objective critical to accomplishing refuge habitat goals.

Because water levels cannot be managed outside the levee system, large-scale marsh restoration projects are generally the only habitat management methods that directly benefit tidal marsh. Within the levee system, counteractive restoration projects such as water level management, marsh grass planting, and small-scale shoreline protection projects have been implemented to slow erosion, trap sediment, and promote vegetation establishment. However, given the significant loss sustained and the urgency of the threats, larger-scale restoration projects are needed. Examples of these projects include dedicated dredging, beneficial dredging, terracing, and wetland assimilation through wastewater treatment.

Marsh restoration projects are costly (starting at $50-70K/acre), and funding opportunities for these efforts are not readily available on an annual basis. However, CWPPRA has and will continue to serve as a vital potential funding source for the refuge. The most recent CWPPRA project on the refuge involved the installation of a rock breakwater dike along the Bayou Chevee and the Lake Pontchartrain bank as shoreline protection and brackish tidal marsh restoration.

As such opportunities arise the refuge would restore fresh/intermediate marsh on a case-by-case basis, with Units 1a, 3, and 6 as priorities. Potential projects are listed in Appendix F.

Resources of Concern: waterfowl, secretive marsh birds.

CCP Objectives 2.4 and 2.5, pages 51 – 52.

Adaptive Management Monitoring Elements:

Primary Habitat Response Variables	**Probable Assessment Methods**
▪ Acreage of emergent marsh ▪ Percent cover of marsh vegetation	▪ GIS habitat assessments ▪ Vegetation surveys
Primary Wildlife Response Variables	**Probable Assessment Methods**
▪ Waterfowl abundance ▪ Shorebird abundance ▪ Breeding rail abundance	▪ Waterfowl surveys ▪ Shorebird surveys ▪ Rail call-back surveys

HABITAT MANAGEMENT OBJECTIVE 4: MARSH MANAGEMENT

Over the next 15 years, manage existing freshwater and intermediate marsh in Units 2, 3, 4, 5, and 6 to promote vegetation growth and establishment, while maintaining sufficient soil hydration to reduce/eliminate subsidence occurring through oxidation of organic materials. Specific conditions for freshwater and intermediate marsh are:

- Exotic invasive plants are maintained each year to levels at which they do not materially affect habitat quality for the resources of concern
- Exotic invasive animals are maintained at levels below which significant resource damage (nutria eat-outs, damage to levees, hog rooting, and hog predation on ground-nesting birds) occurs.
- Fire return interval is 2-3 years (approximating estimates of natural fire return interval for oligohaline marsh).

Rationale: Freshwater marsh is an extremely productive habitat type. Waterfowl use of refuge impoundments has been correlated with moist-soil plant production, and secretive marsh birds and resident waterfowl depend on dense marsh vegetation for nesting. Freshwater marsh management within the refuge primarily consists of managing water levels using water control structures and outgoing pumps. This is accomplished through lowering water levels during the growing season to promote germination and growth of marsh vegetation. However, when allowed to dry for extended periods of time, organic deposits within Bayou Sauvage undergo decomposition with an associated drop in elevation. Because of the salt left over from inundation during Hurricane Katrina, dewatering of these soils can lead to extremely saline conditions. Therefore, without a reliable water supply, it is important to cautiously facilitate vegetation growth and establishment while maintaining sufficient soil hydration.

While the Service strives to provide habitat diversity for a range of native wildlife, there are nonnative or nuisance species that are destructive to critical habitat and out-compete native wildlife for available food resources. Surveys have indicated that approximately 100,000 acres of Louisiana coastal wetlands can be impacted by nutria at any one point in time (Mouton et al. 2001). Impacts can range from heavy grazing to conversion to open water. Feral hogs can significantly damage and alter habitats by impacting vegetation structure and regeneration, soil properties, nutrient cycling, and water infiltration. Hogs can also increase the spread of invasive species, such as Chinese tallow (Siemann et al. 2009). Hogs prey on salamanders, frogs, fish, snakes, turtles, rodents, eggs and chicks of ground-nesting birds, and white-tailed deer fawns. Control of nutria and feral hog populations is imperative to maintaining habitats for federal trust species and other native wildlife.

Resources of Concern: waterfowl, secretive marsh birds, shorebirds.

CCP Objective 2.4, pages 51 – 52.

Adaptive Management Monitoring Elements:

Primary Habitat Response Variables	Probable Assessment Methods
▪ Acreage of freshwater emergent marsh ▪ Percent cover of seed/tuber producing moist-soil plants ▪ Abundance of depredation sites (eat-outs) by nutria ▪ Abundance of hog rooting/sites of habitat degradation	▪ GIS habitat assessments ▪ Vegetation surveys ▪ Document nutria depredation sites during annual vegetation surveys and as encountered ▪ Document hog rooting as encountered
Primary Wildlife Response Variables	**Probable Assessment Methods**
▪ Waterfowl abundance ▪ Shorebird abundance ▪ Breeding rail abundance ▪ Abundance of nutria encounters ▪ Feral hog density ▪ Frequency of hog encounters	▪ Waterfowl surveys ▪ Shorebird surveys ▪ Rail call-back surveys ▪ Document nutria as encountered ▪ Use of wildlife/trail cameras ▪ Document hogs as encountered

HABITAT MANAGEMENT OBJECTIVE 5: FIRE MANAGEMENT

Over the 15-year life of this plan, manage and maintain a prescribed fire program for marsh habitat portions of Units 2, 3, and 4 dominated by Spartina patens to simulate a natural fire regime (fire return interval = 5 years), to help control woody and exotic species, remove excess litter, and encourage the growth of native vegetation.

Rationale: Fire is a natural process that plays a critical role in the dynamics of habitats represented within the refuge. Historically, naturally caused lightning fires and anthropogenic fires burned the forests and marsh surrounding Lake Pontchartrain. Fire management on the refuge consists of both wildfire suppression and prescribed burning. Fire is necessary to reduce hazardous accumulation of fuels, restore native fire-adapted communities, and meet other habitat objectives such as controlling nonnative invasive species (Brooks and Lusk 2008) and setting back succession. Wildfires that occur on the refuge are started by lightning strikes or from human activities under non-controlled conditions. Wildfires occur every year on the refuge. During the period from 1990 to September 2012, there were 121 wildfires that burned over 2,340 acres on the refuge. Where appropriate and in accordance with the refuge's Fire Management Plan, naturally ignited wildfires may be monitored for resource benefit. The current Fire Management Plan (U.S. Fish and Wildlife Service 2008) does not allow for this action, but future versions may.

Resources of Concern: Dabbling ducks, shorebirds, and secretive marsh birds.

CCP Objective 2.7, page 53.

Adaptive Management Monitoring Elements:

Primary Habitat Response Variables	**Probable Assessment Methods**
▪ Acreage burned (prescribed and wild) ▪ Species composition and diversity	▪ Post-burn assessments ▪ Vegetation surveys
Primary Wildlife Response Variables	**Probable Assessment Methods**
▪ Waterfowl abundance ▪ Breeding rail abundance ▪ Shorebird abundance and richness	▪ Waterfowl surveys ▪ Rail call-back surveys ▪ Christmas bird counts

V. Management Strategies

FRESHWATER MARSH MANAGEMENT STRATEGIES

POTENTIAL STRATEGIES

- Freshwater marsh impoundments (Units 2, 3, 4, 5, and 6) provide plant and animal foods that are a critical part of the diet of migrating and wintering waterfowl, and these strategies have become a significant part of management efforts on many refuges. Preferred moist-soil plants provide seeds and other plant parts (e.g., leaves, roots, and tubers) that generally have low deterioration rates after flooding, and provide substantial energy and essential nutrients less available to wintering waterfowl in common agricultural grains (i.e., corn, milo, soybeans); (Fredrickson and Taylor 1982; Strader and Stinson 2005).

- Organic soils such as those on Bayou Sauvage NWR complicate traditional water level management. Conventional moist-soil management requires dewatering of soils during a portion of the growing season to allow for seed germination. However, when allowed to dry for extended periods of time, muck soils can decompose with an associated drop in elevation. It has also been shown that dewatering of these soils can lead to extremely acidic conditions. Additionally, following Hurricane Katrina, saline water inundated these impoundments for over 6 months. Thus, relatively high levels of salinity persist in the soils and impact vegetation during xeric conditions. Without a reliable water source, water management of impoundments depends on rainfall and dewatering through the use of pumping stations and screw gate water control structures.

- Manage units as conventional moist-soil units. This would involve using water control structures and pumps to draw down water levels completely during mid- to late-growing season to facilitate germination and establishment of annual moist-soil vegetation and attempting to re-flood during late fall for migrating and wintering waterfowl. This strategy would provide a short-term increase in annual moist-soil vegetation and vegetative food production. However, past management experience indicates that longer-term results would include an increase in subsidence and ultimately conversion to open water.

- Manage units to facilitate maximum moist-soil vegetation establishment and growth (annuals and perennials) while maintaining sufficient soil moisture to prevent/reduce soil oxidation of organic materials and subsidence. This would involve relying on natural evaporation processes to slowly dewater units during spring and summer rather than using pumps and water control structures. This strategy would allow for better maintenance of marsh elevation and is considered a more sustainable management strategy (U.S. Fish and Wildlife Service 2007a).

MANAGEMENT STRATEGY PRESCRIPTIONS

To meet Habitat Management Objective 4, the following strategies will be utilized in Units 3, 4, 5, and 6 to provide habitat beneficial to breeding and wintering waterfowl and other water birds:

- Maintain water levels, primarily through evaporation and occasionally dewatering through water control structures, to promote germination and establishment of vegetation while maintaining sufficient soil moisture. Target water levels should be within -0.5 foot to 0.0 foot of marsh sediment elevation in the spring and summer and within +0.5 foot to +1.0 foot of marsh sediment elevation during fall and winter.

MARSH RESTORATION/REESTABLISHMENT MANAGEMENT STRATEGIES

POTENTIAL STRATEGIES

The most critical issue facing the refuge is land loss, due to subsidence, erosion, major storm events, and saltwater intrusion. Prior to Hurricane Katrina, wetland restoration projects consisted of several small programs such as using recycled Christmas trees and floating islands to decrease wave fetch and facilitate sediment accretion, and small marsh grass planting projects. However, as a result of significant land loss and other negative impacts from Hurricane Katrina, it is now more important for restoration efforts to be focused on larger-scale projects that introduce sediment into the system and produce more sustainable results. Examples of these projects include dedicated dredging, beneficial dredging, and wetland assimilation through wastewater treatment.

- Conduct marsh vegetation plantings. Vegetation plantings are needed to replace damaged and eroded areas of the marsh. These plantings supplement natural propagation, produce additional organic matter, decrease wave fetch, and accelerate the restoration process. Marsh adapted, emergent species such as marsh hay, smooth cordgrass, California bulrush, and giant cutgrass (Zizaniopsis miliacea) should be planted 18 inches to 5 feet apart, depending on size and condition of plants and site characteristics (e.g., wave energy, water depth, and soil compaction). This strategy serves as a volunteer opportunity, as well as an opportunity to cooperate with other agencies/organizations to accomplish refuge objectives.

- Construct dedicated dredging projects and beneficial use of dredging materials. Beneficial use of dredged material is using material from maintenance dredging operations. Dedicated dredging is the deliberate removal of material from one site to restore or enhance another site. Both operations are extremely expensive. Dedicated and beneficial dredging projects can be extremely costly, thus, funding opportunities will almost exclusively be available through CWPPRA and large-scale mitigation projects.

- Construct terracing. Terraces are constructed in open water ponds using dredge material to create emergent marsh and slow the erosion process by decreasing wave fetch.

- Construction of smaller units to facilitate greater water level control for moist-soil management and use select management units for water storage.

- Use alternative freshwater sources for moist-soil management. This may include pumping from New Orleans drainage system, wetland assimilation of treated wastewater effluents, and groundwater wells.

MANAGEMENT STRATEGY PRESCRIPTIONS

To meet Habitat Management Objectives 3 and 4, the following strategies were selected to be used to restore and reestablish emergent marsh on the refuge:

- Conduct vegetative plantings as funding and volunteer opportunities permit in open water ponds in Units 3, 5, and 6; and restoration sites involving dredged material.
- Reestablish/restore emergent marsh (as identified in Appendix F) through funding sources such as CWPPRA, Coastal Impact Assistance Program, and mitigation funds (e.g., USACE mitigation bank, oil spill damages).
- Investigate alternative reliable sources of freshwater, such as wetland assimilation of treated wastewater effluents.
- Investigate potential for use of select management units for water storage capability as supply for other management units and the possibility of pumping from the Maxent Canal.

SHORELINE PROTECTION MANAGEMENT STRATEGIES

POTENTIAL STRATEGIES

Coastal shoreline projects are aimed to decrease or halt shoreline erosion and marsh loss. Most projects are built to withstand high wave action from boat traffic and/or annual storm events. Like marsh restoration, shoreline protection projects on Bayou Sauvage NWR should focus on large-scale, sustainable projects. Various types of shoreline protection projects have been tested throughout the Gulf, including rock breakwaters, seawalls, earthen levees, and artificial oyster reefs. Artificial oyster reefs may only be functional in Lake St. Catherine due to relatively low salinity levels in Lake Pontchartrain. The completion of several shoreline stabilization projects over the past two decades have resulted in over 2.5 miles of rock breakwater near Bayou Chevee and have proven effective during Hurricane Katrina and constant high wave action from Lake Pontchartrain (Richard 2009).

- Construct concrete or rock dikes along marsh edge to serve as breakwaters. Breakwaters slow erosion by dissipating wave energy caused by watercraft, wind, and storm surges. These breakwaters would be most effectively used outside the hurricane protection levee (i.e., in Lake Pontchartrain and Lake St. Catherine) to dissipate the most intensive wave energy.

- Construct artificial oyster reefs. The bioengineered oyster reef is constructed by placing modular units into an open interlocked configuration. The structure is expected to grow into an oyster reef. As successive generations of oysters settle on the structure, its ability to dissipate wave energy increases. Artificial oyster reefs are lighter than concrete and rock breakwaters, and therefore may be more effective due to the poor load bearing characteristics of the soils on the refuge.

- Use organic materials, such as Christmas trees and artificial floating islands, to create organic wave breaks and build marsh platforms. Decreasing wave energy allows suspended sediment to settle, increasing marsh elevation. Additionally, decreased turbidity increases sunlight penetration, facilitating plant germination. This strategy will most effectively be used within the hurricane protection levee, where wave energy is relatively low.

MANAGEMENT STRATEGY PRESCRIPTIONS

To meet Habitat Management Objectives 4 and 5, the following strategies will be employed in Units 1, 3, 5, 6, 7, and 9 to help slow erosion processes and protect the loss of refuge resources:

- Construct a concrete or rock dike along the outside of Units 1a and 9, starting at the connection of Chef Pass and Lake Pontchartrain. Funding for this project may become available through CWPPRA or mitigation/restoration opportunities.
- Construct oyster reef blocks along the outside of Unit 7a and 7b. Funding for this project may become available through CWPPRA or mitigation/restoration opportunities.
- Use the annual New Orleans Christmas Tree Recycling Program to create organic wave breaks and build marsh platforms in units 1, 3, and 5.
- Use and investigate alternative methods of plant propagation and establishment, such as floating islands in Units 1, 3, and 5.

CHEMICAL MANAGEMENT STRATEGIES

POTENTIAL MANAGEMENT STRATEGIES

Chinese tallow, chinaberry, cogon grass *(Imperata cylindrica),* water hyacinth *(Eichhornia crassipes),* and alligator weed (*Alternanthera philoxeroides)* are nonnative invasive plants that exist on the refuge (Appendix A). The current primary habitat threat and problematic species is Chinese tallow, which can eventually monopolize an area replacing native species. Several chemical treatment methods may be considered to control the spread of tallow, including hack-and-squirt injection, foliar treatment, and basal stem treatment (Miller 2003). In 2007, hack-and-frill and foliar treatments were applied to 2,500 acres within Units 1, 2, 3, 4, 5, 6, and 8. These treatments had limited effectiveness and additional treatments will be needed to maintain control of the species and allow for target woody species to mature and develop canopy closure. Approved chemicals for the treatment of exotic plants will be used that provide the best control and may require maximum label application rates for effective control. Invasive species will be controlled to provide the refuge's ability to create desired habitat conditions and not be outcompeted by the exotic species. The presence of exotic species will be allowed and controlled to a point that it doesn't prevent the refuge's ability to carry out desired wildlife and habitat management objectives. Highest treatment sites will also be placed in areas where the highest visitor service activities are conducted. Without the establishment of a native tree canopy, the treatment of tallow trees is cost prohibitive.

Water hyacinth and alligator weed are nonnative invasive species that provide little food value to focal species. Management typically involves a combination of harvesting, herbicidal application, and biological control. However, within the refuge, coverage of these species is not to an extent that undermines refuge habitat objectives. Moreover, by decreasing erosion and trapping sediment, hyacinth provides some protection against the primary and more immediate threat to the refuge – land loss.

A. Foliar spray nonnative invasive woody vegetation (i.e., Chinese tallow and chinaberry). Foliar spraying may be used on tallow and chinaberry trees <5 feet tall, due to limited access to foliage >5 feet. In south Louisiana, this strategy requires relatively high treatment frequency (i.e., 1 – 3 years) and may be most effectively applied annually from June – October.

B. Basal bark treatment for nonnative invasive woody vegetation (i.e., Chinese tallow and chinaberry). Basal spraying involves spraying the basal bark of the tree and may be used on tallow and chinaberry trees with <6 in. basal bark diameter. This strategy may be used less frequently than foliar spray (i.e., 2 – 4 years) and is most effective during May and June. For best long-term results, it is important to treat trees prior to reproductive maturity (i.e., <3 years). Both basal and foliar spray strategies are especially important at reforestation sites.

C. Hack and squirt injection and cut stump treatments for nonnative, invasive woody vegetation (i.e., Chinese tallow and chinaberry). Hack and squirt injections and cut stump treatments are needed to treat trees >4.5 in. dbh. This strategy is much more labor intensive than basal and foliar spray, but treatment frequency is lower (>5 years). For management objective purposes, this strategy may be considered a more reactive strategy than proactive, as trees are able to mature and reproduce prior to treatment. Furthermore, due to the labor intensity, this strategy typically requires the availability of dedicated funding.

D. Spray nonnative, invasive herbaceous vegetation (i.e., cogon grass, water hyacinth and alligatorweed). The use of chemicals is one of the most effective treatments to control nonnative vegetation. This strategy would set back invasive plants that displace native vegetation beneficial to waterfowl and other wetland-dependent species (Strader and Stinson 2005). However, given the fragile soil characteristics and rate of marsh loss in this region, the displacement of nonnative plants does not always result in vegetation replacement. The loss of vegetation may result in loss of soil stability and increased erosion in areas sprayed for water hyacinth or alligator weed. Areas sprayed for cogon grass may need double treatment and also need replacement with native vegetation to prevent recolonization by cogon grass.

E. Spray undesirable herbaceous vegetation, e.g., cattail *(Typha spp.)* and poison bean *(Sesbania spp.),* in support of moist-soil management to maximize food production for migrating and wintering waterfowl. The use of chemicals to set back undesirable vegetation is a common practice in moist-soil management (Strader and Stinson 2005). However, given the fragile soil characteristics and rate of marsh loss in this region, the loss of any vegetation may result in loss of soil stability and increased erosion.

MANAGEMENT STRATEGY PRESCRIPTIONS

In support of Habitat Management Objectives 2 and 4, the following strategies will be employed in Units 1, 2, 3, 4, 5, 6, and 8 as part of exotic plant control efforts:

- Control the spread of Chinese tallow and chinaberry trees at priority sites using a combination of foliar spray and basal bark treatments every 1 – 3 years in areas that forest restoration is needed to achieve <5 percent coverage. Priority sites include the Ridge Trail reforestation site, any future reforestation sites, and along levees and spoil banks in Units 2, 3, 4, 5, 6, and 8. For non-priority areas, hack and squirt injection will be used as funding permits every 5 – 7 years or as needed to maintain tallow density <100 trees per acre. Once native forest canopy develops, further chemical treatment is not needed until the canopy breaks down. This strategy will additionally require partnerships with educational institutions, non-profit groups, and other organizations to promote recruitment and use of volunteers in control efforts.
- Seek funding through the Service's invasive species control program for additional control efforts. Such efforts would include Potential Management Strategies A – C through contracts and/or partnerships as mentioned above.

FOREST MANAGEMENT STRATEGIES

POTENTIAL STRATEGIES

Forests along natural ridges and levees of the refuge are considered coastal hardwood forests and are characterized by maritime and mixed hardwood species capable of withstanding harsh conditions such as storm events, changes in salinity, sand deposition, and erosion. Coastal hardwood forests within Bayou Sauvage NWR serve as important staging habitat for trans-Gulf migratory songbirds. Desirable forest species include oak *(Quercus spp.),* sugarberry *(Celtis laevigata),* cypress *(Taxodium distichum),* American elm *(Ulmus americana),* Red mulberry *(Morus rubra),* persimmon *(Diospyros virginiana),* red maple *(Acer rubrum),* and black willow *(Salix nigra);* and understory species include *Ilex* spp., palmetto *(Sabal minor),* swamp dogwood *(Cornus drummondii),* and swamp bay *(Persea palustris).* Management techniques to promote mature maritime forest and canopy closure include control of exotic trees, such as Chinese tallow, site preparation methods (e.g., mowing and roller-chopping), tree plantings, and release/improvement treatments to set back less desirable species. Each of these methods is considered labor intensive, and therefore typically requires the availability of dedicated funding.

Prior to reforestation, site characteristics, such as salinity, hydrology, and soil type, must be assessed to determine site suitability. For example, due to flooding from Hurricane Katrina, soil salinity levels within the levee system still remain high in certain areas, and the level of salinity may become toxic to some species during xeric conditions.

A. Plant desirable forest species at selected sites along natural ridges, levees, and spoil banks. This strategy may require site preparation, such as mowing, roller-chopping, or herbicide treatment of exotic trees. Cypress, black willow, green ash, and red maple can be planted at lower elevations, while live oak, sugarberry, and water oak should be planted at higher elevations. The trees should be planted at 10-foot spacing, and predator guards should be used to prevent damage caused by rabbits, rats, and nutria.

B. Use release or improvement treatments to set back less desirable tree and shrub species, which may include Chinese tallow and chinaberry, as well as other less-desirable native species. Release/improvement treatment, however, is an intensive management strategy and may not be necessary to achieve historic native coastal forest conditions.

MANAGEMENT STRATEGY PRESCRIPTIONS

To meet Habitat Management Objective 2, the following strategies will be used as part of the forest restoration activities on the refuge:

- Reforest desirable forest species (i.e., live oak, water oak, sugarberry, red maple, green ash, and cypress). Reforestation would also be complemented with appropriate herbicide treatment. Priority reforestation sites will include:
    - Along pipeline canals and natural ridges in Unit 3 (approximately 120 acres)
    - Along Interstate 10 and the base of the Hurricane Protection Levee in Unit 2 (approximately 140 acres)
    - South Point in Unit 2 (approximately 100 acres)

- Between Highway 11 and the Hurricane Protection Levee in Unit 4 (approximately 34 acres)
- Along Chef Highway and the base of the Hurricane Protection Levee in Units 5 and 6 (approximately 100 acres)
- Any new land acquisitions with potential to provide quality forested habitat.

NUTRIA/FERAL HOG MANAGEMENT STRATEGIES

POTENTIAL STRATEGIES

Nutria and feral hog are nonnative species that have the ability to significantly alter and degrade refuge habitat (Appendix E). Several control methods may be used to reduce nutria populations, including trapping, gunning, and hunting with dogs. The refuge is currently participating in the Louisiana Coastwide Nutria Control Program (CNCP) and issues special use permits annually to allow area trappers to assist in reducing nutria populations. Additionally, incidental shooting by qualified refuge personnel has been effective.

Several aggressive management techniques may be used to eradicate or decrease feral hog populations, most of which can be divided into two categories: shooting and trapping. Trapping, followed by euthanasia, is one of the most popular and effective methods of reducing population density (West et al., 2009). When used with bait, large portable corral traps can be very effective and practical. The refuge is in the process of implementing an aggressive control program, using bait and corral traps, and shooting by qualified refuge personnel. Additionally, a hog monitoring program will be implemented using wildlife/trail cameras to monitor population trends and habitat damage, and assess the success of the control program.

The following are potential strategies for controlling nutria and swine on the refuge. All control methods discussed are authorized by 50 CFR 31.14.

A. Participate in the Louisiana CNCP, and partner with local trappers to reduce nutria and hog populations. Under the CNCP, licensed trappers enrolled in the LDWF program shall be permitted to take nutria by trapping only, within designated management units. This has proven to be a cost effective means to reduce nutria populations on both public and private lands in Louisiana (Coastwide Nutria Control Program, CWPPRA LA-03b).

B. Manage nutria and hog populations through a combination of shooting, trapping, and snares using qualified refuge personnel. Shooting and trapping by refuge personnel are currently being used and have been effective. For example, 1,673 nutria have been removed by shooting since 1998; in the last two years, nutria sightings have decreased significantly. A monitoring program will be implemented to assess the success of the control methods and facilitate the adaptive management process. The target nutria population will be <3/acre, which is considered the average carrying capacity for coastal Louisiana. The target for hogs will be eradication, and subsequently to maintain the population at the lowest possible level. If eradication appears to be successful, surveys should continue in case estimates were low or to detect immigration.

C. Contract an intensive nutria control program through USDA or a private contractor potentially using traps, dogs, GPS tracking systems, and/or gunning. A combination of methods may be used through an intensive program using trained personnel to eradicate or significantly reduce

the nutria population on the refuge (Jojola et al. 2005). However, this is a very expensive program, and given the current population status across the Gulf region, results of the program would be temporary. Therefore, this program may not be cost-effective.

D. The use of aerial gunning by trained Service employees or by USDA contract can be an effective feral hog removal technique. GPS tracking systems and/or dogs can also be used in some situations. A combination of trapping, shooting, and the use of dogs to control hog populations can be highly effective (McCann and Garcelon 2008). Aerial shooting from helicopters in particular can be very effective (Saunders and Bryant 1987). However, effects of disturbance to migratory and nesting waterbirds would need to be evaluated prior to implementation.

E. Open the refuge to public hunting of feral hogs. Public hunting on national wildlife refuges, state wildlife management areas, and private lands has been a time honored method of attempting to control feral hogs throughout the United States. However, in order for hunting pressure to effectively control hog populations, it should be focused on mature sows during years of poor mast production and on juveniles during years of high mast production (Bieber and Ruf 2005). A "Refuge Opening Hunt Package" including a hunt plan, compatibility determination, and the proper NEPA documentation would be needed.

MANAGEMENT STRATEGY PRESCRIPTIONS

To meet Habitat Management Objectives 3 and 5, the following strategies will be used to control nutria and feral hog populations:

- Conduct yearly evaluations of nutria and feral hog populations on refuge lands, using established monitoring protocols.
- Partner with area trappers to reduce nutria and feral hog populations.
- Participate in the State of Louisiana Nutria Control program by actively promoting the program and seeking assistance from area trappers to reduce nutria populations on refuge lands consistent with the state's Nuisance Animal Control Plan.
- Manage nutria and hog populations through a combination of shooting, trapping, and snares using qualified refuge personnel.

FIRE MANAGEMENT STRATEGIES

POTENTIAL STRATEGIES

Fire management strategies on the refuge may range from a wildfire suppression-only approach to the application of frequent prescribed fire. Department of the Interior policy requires that every area with burnable vegetation have an approved Fire Management Plan. These plans must address potential wildfire occurrences and may include the full range of appropriate management responses. Wildfires are a common occurrence on the refuge, and given the juxtaposition of the refuge and New Orleans infrastructure, public safety is a primary concern. Therefore, at a minimum, it is essential for the refuge to maintain a Fire Management Plan that addresses wildfire suppression. Because of the refuge proximity to major roadways and the city of New Orleans, wildfire suppression will always be a necessary component of fire management on the refuge.

Prescribed burns are commonly used in marsh habitats to promote desirable vegetative communities, control invasive exotic species, and reduce fuel levels. However, the majority of refuge soils have organic horizons susceptible to ground fire under drought conditions. Therefore, prescribed burn conditions must be dry enough for fire to carry through the marsh yet wet enough to prevent injurious muck (ground) fires. With current and anticipated infrastructure on the refuge, control of water levels is imprecise, allowing drainage at certain times but not filling of marsh areas. Consequently, water level management rarely results in water levels/soil conditions conducive to burning. Also, because of the proximity of major roadways and other smoke-sensitive areas, smoke management adds an additional layer of complexity to burn prescriptions, effectively ruling out many otherwise favorable days for burning. The following potential strategies describe the range of possibilities for habitat management with fire on Bayou Sauvage NWR:

A. Use prescribed fire to manage intact intermediate marsh within the hurricane protection levees. This strategy would consist of applying prescribed fire on a 3- to 5-year return interval to marsh habitat with *Spartina patens* cover of sufficient continuity to carry fire. These habitats occur in Units 2, 3, and 4. Prescribed fire in this habitat type would be for the purposes of setting back woody plants including invasive exotics, removing excess fuel, and encouraging the growth of early successional, large-seeded grasses and sedges which produce food for waterfowl. Care would have to be taken to ensure that organic soils were fully saturated and/or inundated to a depth of 1 to 2 inches to prevent ground fires.

B. Use prescribed fire to manage marsh outside the hurricane protection levees. This strategy would consist of applying periodic prescribed fire to brackish tidal marshes outside the levees. Given concerns that burning marshes in areas where subsidence is taking place is of questionable value, and given that no clear resource benefits have been identified from this strategy, it has not been selected.

C. Utilize naturally ignited wildfires to achieve resource objectives by structuring suppression efforts such that, under selected conditions and in selected areas, wildfires are allowed to burn. Two factors complicate this strategy. First, naturally ignited wildfires are rare on the refuge; only 5 on-refuge wildfires since 1996 have been designated as having been naturally ignited. These fires burned a total of 200 acres, and the single one which required suppression burned 166 of those acres. The possibility that a naturally ignited wildfire could occur under conditions which would both allow the fire to have the intended resource effects and also not jeopardize habitat or public safety is vanishingly small. Second, the current refuge Fire Management Plan, as already noted, rules out all wildland fire use. This plan would need to be changed before this strategy could be implemented. For these reasons, using wildfire to benefit resources on Bayou Sauvage NWR will probably never be a significant habitat management strategy. The decision on whether to change the refuge Fire Management Plan to allow the use of wildfires for resource benefit will need to be made in light of these constraints.

D. Wildfire suppression only. Suppressing wildfires, as noted above, is a baseline strategy for Bayou Sauvage NWR. Suppression strategies and tactics are covered in the Fire Management Plan. The decision not to use prescribed fire, however, is a habitat management decision, and should be made with an understanding of the likely effects on the resource. Eschewing prescribed fire on Bayou Sauvage NWR will limit options for setting back succession to shrubland and controlling invasive exotic weeds (chiefly Chinese tallow at present) in marsh habitat. Chemical and mechanical control methods are extremely difficult to implement on marsh soils.

MANAGEMENT STRATEGY PRESCRIPTIONS

The following strategies will be implemented to meet Habitat Management Objective 5:

- Apply prescribed fire on a roughly 5-year return interval to marsh habitat in Units 2, 3, and 4 with *Spartina patens* cover of sufficient continuity to carry fire.
- Prescribed fire objectives will include:
    - setting back woody plants including invasive exotics,
    - removing excess fuel, and
    - encouraging the growth of early successional, large-seeded grasses and sedges which produce food for waterfowl.
- Prescription conditions will include:
    - Organic soils are fully saturated and/or inundated to a depth of 1 to 2 inches to prevent ground fires;
    - Wind speed and direction, relative humidity, and other conditions selected to allow safe completion of the burn while consuming most or all fine fuel above the water line;
    - Burns can be conducted in any season, but favor growing season to have greater effect on woody plants.

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APPENDIX C. REFUGE BIRDS

Bird species known from Bayou Sauvage NWR, Orleans Parish, Louisiana (U.S. Geological Survey 1995)

COMMON NAME	SCIENTIFIC NAME
Common Loon	*Gavia immer*
Pied-billed Grebe*	*Podilymbus podiceps*
Horned Grebe	*Podiceps auritus*
Eared Grebe	*Podiceps nigricollis*
American White Pelican	*Pelecanus erythrorhynchos*
Brown Pelican	*Pelecanus occidentalis*
Masked Booby	*Sula dactylatra*
Double-crested Cormorant	*Phalacrocorax auritus*
Anhinga*	*Anhinga anhinga*
Magnificent Frigatebird	*Fregata magnificens*
American Bittern	*Botaurus lentiginosus*
Least Bittern*	*Ixobrychus exilis*
Great Blue Heron*	*Ardea herodias*
Great Egret*	*Ardea alba*
Snowy Egret*	*Egretta thula*
Little Blue Heron*	*Egretta caerulea*
Tri-colored Heron*	*Egretta tricolor*
Reddish Egret	*Egretta rufescens*
Cattle Egret*	*Bubulcus ibis*
Green Heron*	*Butorides virescens*

COMMON NAME	SCIENTIFIC NAME
Black-crowned Night Heron*	*Nycticorax nycticorax*
Yellow-crowned Night Heron*	*Nyctanassa violacea*
White Ibis*	*Eudocimus albus*
Glossy Ibis*	*Plegadis falcinellus*
White-faced Ibis*	*Plegadis chihi*
Roseate Spoonbill	*Platalea ajaja*
Wood Stork	*Mycteria americana*
Fulvous Whistling Duck	*Dendrocygna bicolor*
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Canada Goose	*Branta canadensis*
Wood Duck*	*Aix sponsa*
Green-winged Teal	*Anas crecca*
Mottled Duck*	*Anas fulvigula*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Eurasian Wigeon	*Anas penelope*
Canvasback	*Aythya valisineria*

COMMON NAME	SCIENTIFIC NAME
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Long-tailed Duck	*Clangula hyemalis*
Black Scoter	*Melanitta nigra*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Common Goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullatus*
Red-breasted Merganser	*Mergus serrator*
Ruddy Duck	*Oxyura jamaicensis*
Black Vulture	*Coragyps atratus*
Turkey Vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
American Swallow-tailed Kite	*Elanoides forficatus*
Mississippi Kite*	*Ictinia mississippiensis*
Bald Eagle*	*Haliaeetus leucocephalus*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperi*
Red-shouldered Hawk*	*Buteo lineatus*

COMMON NAME	SCIENTIFIC NAME
Broad-winged Hawk	*Buteo platypterus*
Red-tailed Hawk	*Buteo jamaicensis*
Rough-legged Hawk	*Buteo lagopus*
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
King Rail*	*Rallus elegans*
Clapper Rail*	*Rallus longirostris*
Virginia Rail	*Rallus limicola*
Yellow Rail	*Coturnicops noveboracensis*
Sora	*Porzana carolina*
Purple Gallinule*	*Porphyrio martinica*
Common Moorhen*	*Gallinula chloropus*
American Coot	*Fulica americana*
Black-bellied Plover	*Pluvialis squatarola*
American Golden-Plover	*Pluvialis dominica*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer*	*Charadrius vociferus*
Black-necked Stilt*	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Willet	*Tringa semipalmata*

COMMON NAME	SCIENTIFIC NAME
Solitary Sandpiper	*Tringa solitaria*
Spotted Sandpiper	*Actitis macularia*
Upland Sandpiper	*Bartramia longicauda*
Ruddy Turnstone	*Arenaria interpres*
Marbled Godwit	*Limosa fedoa*
Sanderling	*Calidris alba*
Baird's Sandpiper	*Calidris bairdii*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
White-rumped Sandpiper	*Calidris fuscicollis*
Pectoral Sandpiper	*Calidris melanotos*
Dunlin	*Calidris alpina*
Stilt Sandpiper	*Calidris himantopus*
Short-billed Dowitcher	*Limnodromus griseus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Wilson’s Snipe	*Gallinago delicata*
American Woodcock	*Scolopax minor*
Wilson's Phalarope	*Phalaropus tricolor*
Laughing Gull	*Larus atricilla*
Bonaparte's Gull	*Larus philadelphia*
Ring-billed Gull	*Larus delawarensis*
Herring Gull	*Larus argentatus*

COMMON NAME	SCIENTIFIC NAME
Gull-billed Tern	*Sterna nilotica*
Caspian Tern	*Sterna caspia*
Royal Tern	*Sterna maxima*
Sandwich Tern	*Sterna sandvicensis*
Forster's Tern	*Sterna forsteri*
Least Tern	*Sterna antillarum*
Black Tern	*Childonias niger*
Black Skimmer	*Rhynchops niger*
Rock Pigeon (introduced)	*Columba livia*
Mourning Dove*	*Zenaida macroura*
Common Ground-Dove*	*Columbina passerina*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Yellow-billed Cuckoo*	*Coccyzus americanus*
Groove-billed Ani	*Crotophaga sulcirostris*
Barn Owl*	*Tyto alba*
Eastern Screech-Owl*	*Otus asio*
Great Horned Owl*	*Bubo virginianus*
Barred Owl*	*Strix varia*
Common Nighthawk*	*Chordeiles minor*
Chuck-will's-widow*	*Caprimulgus carolinensis*
Whip-poor-will	*Caprimulgus vociferus*
Chimney Swift	*Chaetura pelagica*
Ruby-throated Hummingbird*	*Archilochus colubris*

COMMON NAME	SCIENTIFIC NAME
Belted Kingfisher	*Ceryle alcyon*
Northern Bobwhite	*Colinus virginianus*
Eastern Bluebird	*Sialia sialis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-bellied Woodpecker*	*Melanerpes carolinus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Downy Woodpecker*	*Picoides pubescens*
Hairy Woodpecker*	*Picoides villosus*
Northern Flicker*	*Colaptes auratus*
Olive-sided Flycatcher	*Contopus cooperi*
Eastern Wood-Pewee	*Contopus virens*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Acadian Flycatcher*	*Empidonax virescens*
Alder Flycatcher	*Empidonax alnorum*
Least Flycatcher	*Empidonax minimus*
Eastern Phoebe	*Sayornis phoebe*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Great-crested Flycatcher*	*Myiarchus crinitus*
Great Kiskadee	*Pitangus sulphuratus*
Eastern Kingbird*	*Tyrannus tyrannus*
Western Kingbird	*Tyrannus verticalis*
Scissor-tailed Flycatcher	*Tyrannus forficatus*

COMMON NAME	SCIENTIFIC NAME
Purple Martin*	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow*	*Hirundo rustica*
Blue Jay*	*Cyanocitta cristata*
American Crow*	*Corvus brachyrhynchos*
Fish Crow*	*Corvus ossifragus*
Carolina Chickadee*	*Poecile carolinensis*
Tufted Titmouse*	*Baeolophus bicolor*
Red-breasted Nuthatch	*Sitta canadensis*
Brown Creeper	*Certhia americana*
Carolina Wren*	*Thryothorus ludovicianus*
House Wren	*Troglodytes aedon*
Winter Wren	*Troglodytes troglodytes*
Sedge Wren	*Cistothorus platensis*
Marsh Wren*	*Cistothorus palustris*
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*
Blue-gray Gnatcatcher*	*Polioptila caerulea*
Veery	*Catharus fuscescens*
Gray-cheeked Thrush	*Catharus minimus*

COMMON NAME	SCIENTIFIC NAME
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
Wood Thrush	*Hylocichla mustelina*
American Robin	*Turdus migratorius*
Gray Catbird	*Dumetella carolinensis*
Northern Mockingbird*	Mimus polyglottos
Brown Thrasher*	*Toxostoma rufum*
American Pipit	*Anthus rubescens*
Cedar Waxwing	*Bombycilla cedrorum*
Loggerhead Shrike*	*Lanius ludovicianus*
European Starling (Introduced)*	*Sturnus vulgaris*
White-eyed Vireo*	*Vireo griseus*
Blue-headed Vireo	*Vireo solitarius*
Yellow-throated Vireo*	*Vireo flavifrons*
Warbling Vireo	*Vireo gilvus*
Philadelphia Vireo*	*Vireo philadelphicus*
Red-eyed Vireo*	*Vireo olivaceus*
Blue-winged Warbler	*Vermivora pinus*
Golden-winged Warbler	*Vermivora pinus*
Tennessee Warbler	*Vermivora peregrina*
Nashville Warbler	*Vermivora ruficapilla*
Orange-crowned Warbler	*Vermivora celata*
Northern Parula*	*Parula americana*

COMMON NAME	SCIENTIFIC NAME
Yellow Warbler	*Dendroica petechia*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Magnolia Warbler	*Dendroica magnolia*
Yellow-rumped Warbler	*Dendroica coronata*
Black-throated Green Warbler	*Dendroica virens*
Blackburnian Warbler	*Dendroica fusca*
Yellow-throated Warbler*	*Dendroica dominica*
Pine Warbler	*Dendroica pinus*
Prairie Warbler	*Dendroica discolor*
Palm Warbler	*Dendroica palmarum*
Bay-breasted Warbler	*Dendroica castanea*
Blackpoll Warbler	*Dendroica striata*
Cerulean Warbler	*Dendroica cerulea*
Black-and-white Warbler	*Mniotilta varia*
American Redstart	*Setophaga ruticilla*
Prothonotary Warbler*	*Protonotaria citrea*
Worm-eating Warbler	*Helmitheros vermivora*
Swainson's Warbler	*Limnothlypis swainsonii*
Ovenbird	*Seiurus aurocapillus*
Northern Waterthrush	*Seiurus noveboracensis*
Louisiana Waterthrush	*Seiurus motacilla*
Kentucky Warbler	*Oporornis formosus*
Mourning Warbler	*Oporornis philadelphia*

COMMON NAME	SCIENTIFIC NAME
Common Yellowthroat*	*Geothlypis trichas*
Hooded Warbler*	*Wilsonia citrina*
Wilson's Warbler	*Wilsonia pusilla*
Canada Warbler	*Wilsonia canadensis*
Yellow-breasted Chat*	*Icteria virens*
Summer Tanager	*Piranga rubra*
Scarlet Tanager	*Piranga olivacea*
Northern Cardinal*	*Cardinalis cardinalis*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Blue Grosbeak	*Passerina caerulea*
Indigo Bunting	*Passerina cyanea*
Painted Bunting*	*Passerina ciris*
Purple Finch	*Carpodacus purpureus*
Pine Siskin	*Carduelis pinus*
American Goldfinch	*Carduelis tristis*
Eastern Towhee*	*Pipilo erythrophthalmus*
Dickcissel	*Spiza americana*
Chipping Sparrow	*Spizella passerina*
Clay-colored Sparrow	*Spizella pallida*
Field Sparrow	*Spizella pusilla*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Savannah Sparrow	*Passerculus sandwichensis*

COMMON NAME	SCIENTIFIC NAME
Grasshopper Sparrow	*Ammodramus savannarum*
Leconte's Sparrow	*Ammodramus leconteii*
Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*
Seaside Sparrow*	*Ammodramus maritimus*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza georgiana*
White-throated Sparrow	*Zonotrichia albicollis*
White-crowned Sparrow	*Zonotrichia leucophrys*
Dark-eyed Junco	*Junco hyemalis*
Bobolink	*Dolichonyx oryzivorus*
Red-winged Blackbird*	*Agelaius phoeniceus*
Eastern Meadowlark*	*Sturnella magna*
Western Meadowlark*	*Sturnella neglecta*
Rusty Blackbird	*Euphagus carolinus*
Boat-tailed Grackle*	*Quiscalus major*
Common Grackle*	*Quiscalus quiscula*
Bronzed Cowbird	*Molothrus aeneus*
Brown-headed Cowbird*	*Molothrus ater*
Orchard Oriole*	*Icterus spurius*
Baltimore Oriole	*Icterus galbula*
House Sparrow (Introduced)*	*Passer domesticus*

APPENDIX D: LISTED, CANDIDATE, AND RECOVERED SPECIES OF ORLEANS PARISH, LOUISIANA

Group	Name	Population	Status
Birds	**Brown pelican** (*Pelecanus occidentalis*)	except U.S. Atlantic coast, FL, AL	Recovery
	Sprague's pipit (*Anthus spragueii*)		Candidate
Fishes	**Gulf sturgeon** (*Acipenser oxyrinchus desotoi*)		Threatened
	Pallid sturgeon (*Scaphirhynchus albus*)		Endangered
Mammals	**West Indian manatee** (*Trichechus manatus*)		Endangered

APPENDIX E: EXOTIC INVASIVE SPECIES AFFECTING REFUGE HABITATS

In this appendix, exotic plants and animals which significantly impact refuge resources are described, and control measures are summarized.

NONNATIVE PLANTS

Exotic plants can have a significant impact on native habitats, in some cases completely replacing the natural vegetative communities. Nonnative plants have the potential to alter refuge habitats by displacing native plants, changing fire regimes, and altering soil hydrology (Miller 2003). Although a systematic inventory of nonnative plants has not been performed on the refuge, several nonnative plants were identified as currently being the most important species on which to focus management efforts and details. A summary of each of these species is provided below.

CHINESE TALLOW

Chinese tallow *(Triadica sebifera)* is an exotic invasive tree which was introduced to Georgia and South Carolina in the 1700s as a potential crop (the seeds contain a waxy substance which was thought to be commercially valuable). Those early introductions may have come from southern China. Later introductions, made for the horticultural trade, may constitute different ecotypes from more northern sources within the native range of the species, and were more widely disseminated (DeWalt et al., 2011). This species has escaped cultivation and infested millions of acres of coastal plain habitats from Texas to South Carolina. It is capable of converting open fields or coastal prairies to near-monotypic stands within a few years, and can grow on a wide variety of sites, soils, vegetation types, and salinities (Maddox et al., n.d.).

Control options are limited for tallow. Prescribed fire can be used for relatively light infestations in prairie or upland forest; however, denser stands of tallow in prairie systems out-compete herbaceous plants and eliminate most fine fuels (Grace et al. 2005). Herbicides are currently the most effective large-scale treatment for controlling tallowtree (Jubinsky and Anderson 1996). Herbicides which can be used include 2,4-D+2,4-DP, clopyralid (Escort), imazapyr (Arsenal), fosamine (Krenite), hexazinone (Velpar), and triclopyr (Garlon, Pathfinder) (Maddox et al. n.d.).

CHINABERRY

Chinaberry *(Melia azedarach)* is a medium-sized tree in the Meliaceae (mahogany) family which was introduced as an ornamental to the southeastern United States in the early 1800s (IFAS n.d.). It is native to southern Asia and northern Australia, where it has some commercial importance both as a timber tree and as a source of traditional medicines and insecticides. Numerous studies have evaluated various Chinaberry extracts for insecticidal, antifungal, antiviral, and antiparasitic activity; see for example (de Nardo et al. 1997; Szewczuk et al. 2003; Barquero et al. 1997).

Chinaberry seeds are disseminated by birds, and it is considered to be at least moderately invasive in its North American range. Control can be achieved by application of Triclopyr as a foliar, frill, or cut-stump application. Prescribed fire is only marginally useful for control, only effective on small, widely scattered stems, and only capable of top-kill (Waggy 2009).

COGONGRASS

Cogongrass *(Imperata cylindrica)*, first introduced in the early 20th Century to southern Alabama, has spread across the southern tier of states from Texas to Virginia (Evans et al. 2005). It spreads aggressively via rhizomes, and is a prolific seed producer (Bryson and Carter 1993) although outcrossing is necessary for good seed viability (MacDonald 2007). Dozers, tractors, and earth-moving equipment are a major vector of spread, distributing pieces of rhizome which readily take root and form new clones (Bryson and Carter 1993). Cogongrass has become established on levees and other higher areas on the refuge and is complicating the reestablishment of native vegetation that was killed by Hurricane Katrina.

Control of cogongrass can be achieved by herbicide; chemicals and tank mixes which are effective against this species include glyphosate, imazapyr (Arsenal®), and imazapyr+sulfometuron (Oust XP®) (Evans et al. 2005).

WATER HYACINTH

Water hyacinth *(Eichhornia crassipes)* is a floating perennial herb in the monocot family Pontederiaceae. It is native to Brazil and was introduced to the southern United States in 1884 as an ornamental (IFAS 2012). Water hyacinth can double every 11 to18 days (Coetzee et al. 2009) and is thus capable of covering large bodies of water quickly. It completely changes the ecology of formerly open-water habitat by shading out rooted submersed vegetation and reducing animal diversity (Coetzee et al. 2009). Heavy infestations choke waterways and interfere with boat traffic.

An integrated approach to controlling this weed includes mechanical or hand removal for small infestations, herbicide applications for larger infestations, and biological control measures consisting of three insects imported from the native range of the plant (Charudattan 1986). Two weevils *(Neochetina eichhorniae and N. bruchi)* were introduced to the southeastern United States in 1974 and help suppress water hyacinth by burrowing in and feeding on the plant both as adults and larvae. A moth *(Niphograpta albiguttalis),* introduced from Argentina, also contributes to suppressing water hyacinth. The larvae of the moth burrow into the plant, causing necrosis, wilting, and death of plants in some cases (IFAS 2012; Charudattan 1986; Coetzee et al. 2009). However, these biocontrol agents have not been sufficient in and of themselves for achieving the desired level of control of water hyacinth in many areas of the southeastern United States. Herbicides effective against infestations of water hyacinth include 2,4-dichlorophenoxyacetic acid, glyphosate, diquat, and paraquat (Coetzee et al. 2009). Control achieved by herbicides is usually temporary, as propagules usually survive or are readily reintroduced.

NONNATIVE ANIMALS

FERAL HOG

Feral swine *(Sus scrofa)* have been widely introduced into North America and now pose problems for land managers in most areas of the United States. Hogs are prolific and adaptable, able to survive and reproduce in a wide range of habitats and climates. Their omnivorous diet and high reproductive rate combine to make them at once destructive and hard to control. Among their various prey items are the nests of ground-nesting birds and reptiles and young of native mammals such as white-tailed deer *(Odocoileus virginianus)* (Seward et al. 2004).

Control methods in the United States usually consist of some combination of trapping and shooting (Seward et al. 2004). Toxic baits have been used in Australia and other locations (Choquenot et al. 1996), but are problematic because of non-target effects.

NUTRIA

Nutrias *(Myocastor coypus)* are herbivorous aquatic rodents native to South America which damage marsh habitats in the southern United States by grazing and burrowing. They were introduced into Louisiana in 1938 by E.A. McIlhenny of Avery Island for the purpose of fur farming. A hurricane two years later facilitated their escape, and they soon proliferated all along the Gulf coast (Presnall 1958). Resource impacts from nutrias can range from heavily grazed patches (eat-outs) to the complete conversion of emergent marsh vegetation to open water through a combination of heavy grazing and burrowing. Vegetation is destroyed, and easily eroded marsh soils are soon lost. Water control structures can be undermined by their burrowing activities (Carter and Leonard 2002). State surveys of nutria damage in Louisiana have documented damage up to 12,000 acres in one year in Terrebonne Parish alone (Marx, Mouton, and Linscombe 2004).

Control of nutria is by trapping, shooting, or poisoning. As with hogs, use of poisons to control nutria can kill non-target organisms. Shooting can be done in the day or at night, and can be very effective alone or when combined with trapping. Various styles of traps are used, depending on the potential for non-target captures. (LeBlanc 1994).

APPENDIX F: POTENTIAL LARGE-SCALE RESTORATION PROJECTS

Project Description	Estimated Cost	Net Acres Benefited
Dedicated dredging of sediment into the Bayou Chevee Marsh on Bayou Sauvage NWR. This will enhance a shoreline stabilization project that has been constructed. This is a proposed CWPPRA project.	$10,000,000	2,700
Shoreline stabilization of the Brazillier Island tract of Bayou Sauvage NWR. This project will provide shoreline protection to Brazillier Island. Dedicated dredging and deposition of that spoil into open water ponds will restore several acres of emergent brackish marsh. This is a proposed CWPPRA project.	$15,000,000	750
Hydrological restoration of Bayou Sauvage proper. This is the actual bayou that gave rise to the name of the refuge. The bayou has silted in over years. Sediment from dredging the bayou can be pumped back into the open water of Blind Lagoon. This project will result in the hydrological flow of the remnants of the bayou and also restore approximately 100 acres of freshwater marsh. It will also open up additional public use opportunities.	$5,000,000	150
Dedicated dredging of sediment into Unit 3, Blind Lagoon, Bayou Sauvage NWR. This will restore approximately 2,000 acres of freshwater marsh and complement a CWPPRA project funded in 1995.	$20,000,000	2,000
Dedicated dredging of sediment into Unit 6 of Bayou Sauvage NWR. This will restore approximately 2,000 acres of fresh-intermediate marsh and complement a CWPPRA project funded in 1995.	$20,000,000	2,000
Acquisition of lands from willing sellers that can be managed or restored to benefit wildlife and fisheries and to provide opportunities for compatible public uses. Approximately 8,000 acres remain to be acquired within the approved acquisition boundary.	$2,000 per acre	

APPENDIX G. ENVIRONMENTAL ACTION STATEMENT

U. S. FISH AND WILDLIFE SERVICE

ENVIRONMENTAL ACTION STATEMENT FOR CATEGORICAL EXCLUSION

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA), and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and determined that the following proposed action is categorically excluded from NEPA documentation requirements consistent with 40 CFR 1508.4, 516 DM 2.3A, 516 DM 2 Appendix 1, and 516 DM 6 Appendix 1.4.

Proposed Action and Alternatives. The proposed action is the approval and implementation of the Habitat Management Plan (HMP) for Bayou Sauvage National Wildlife Refuge (NWR). This plan is a step-down management plan providing the refuge manager with specific guidance for implementing goals, objectives, and strategies identified in the Bayou Sauvage NWR Comprehensive Conservation Plan (CCP) (U.S. Fish and Wildlife Service 2009a).

The proposed CCP action was the preferred alternative among three alternatives considered in the Environmental Assessment (EA) (U.S. Fish and Wildlife Service 2009b). In the CCP, the proposed action was to Restore and Improve Ecological Diversity and Augment Visitor Services. Implementing the preferred alternative will result in the restoration and improvement of refuge resources needed for wildlife and habitat management, while providing opportunities for a variety of additional compatible wildlife-dependent recreation, education, and interpretive activities. This alternative would also allow the refuge to provide law enforcement protection that adequately meets the demands of an urban environment (U.S. Fish and Wildlife Service 2009a).

The CCP has defined goals, objectives and strategies to achieve the stated action. The actions further detailed in the HMP have been identified, addressed, and authorized by the CCP and accompanying EA (U.S. Fish and Wildlife Service 2009b). These include:

- Maintain water levels, primarily through evaporation and occasionally dewatering through water control structures, to promote germination and establishment of vegetation while maintaining sufficient soil moisture. Target water levels should be within -0.5 ft. to 0.0 ft. of marsh sediment elevation in the spring and summer and within +0.5 to +1.0 ft. of marsh sediment elevation during fall and winter.
- Conduct vegetative plantings as funding and volunteer opportunities permit in open water ponds in units 3, 5, and 6; and restoration sites involving dredged material.
- Reestablish/restore emergent marsh (as identified in Appendix F) through funding sources such as CWPPRA, Coastal Impact Assistance Program, and mitigation funds (e.g., USACE mitigation bank, oil spill damages).
- Investigate alternative reliable sources of freshwater, such as wetland assimilation of treated wastewater effluents.
- Investigate potential for use of select management units for water storage capability as supply for other management units and the possibility of pumping from the Maxent Canal.

- Construct a concrete or rock dike along the outside of units 1a and 9, starting at the connection of Chef Pass and Lake Pontchartrain. Funding for this project may become available through CWPPRA or mitigation/restoration opportunities.
- Construct oyster reef blocks along the outside of unit 7a and 7b. Funding for this project may become available through CWPPRA or mitigation/restoration opportunities.
- Use the annual New Orleans Christmas Tree Recycling Program to create organic wave breaks and build marsh platforms in Units 1, 3, and 5.
- Use and investigate alternative methods of plant propagation and establishment, such as floating islands in Units 1, 3, and 5.
- Control the spread of Chinese tallow and chinaberry trees at priority sites using a combination of foliar spray and basal bark treatments every 1 – 3 years in areas that forest restoration is needed to achieve <5 percent coverage. Priority sites include the Ridge Trail reforestation site, any future reforestation sites, and along levees and spoil banks in Units 2, 3, 4, 5, 6, and 8. For non-priority areas, hack and squirt injection will be used as funding permits every 5 – 7 years or as needed to maintain tallow density <100 trees per acre. Once native forest canopy develops, further chemical treatment is not needed until the canopy breaks down. This strategy will additionally require partnerships with educational institutions, non-profit groups, and other organizations to promote recruitment and use of volunteers in control efforts.
- Seek funding through the Service's invasive species control program for additional control efforts. Such efforts would include *Potential Management Strategies* A – C through contracts and/or partnerships as mentioned above.
- Reforest desirable forest species (i.e., live oak, water oak, sugarberry, red maple, green ash, and cypress). Reforestation would also be complemented with appropriate herbicide treatment. Priority reforestation sites will include: Along pipeline canals and natural ridges in Unit 3, along Interstate 10 and the base of the Hurricane Protection Levee in Unit 2, South Point in Unit 2, between Highway 11 and the Hurricane Protection Levee in Unit 4, along Chef Highway and the base of the Hurricane Protection Levee in Units 5 and 6, and any new land acquisitions with potential to provide quality forested habitat.
- Conduct yearly evaluations of nutria and feral hog populations on refuge lands, using established monitoring protocols.
- Partner with area trappers to reduce nutria and feral hog populations.
- Participate in the State of Louisiana Nutria Control program by actively promoting the program and seeking assistance from area trappers to reduce nutria populations on refuge lands consistent with the state's Nuisance Animal Control Plan.
- Apply prescribed fire on a roughly 5-year return interval to marsh habitat in Units 2, 3, and 4 with *Spartina patens* cover of sufficient continuity to carry fire.

Categorical Exclusion(s). Categorical Exclusion Department Manual 516 DM 6, Appendix 1 Section 1.4 B (10), which *states "the issuance of new or revised site, unit, or activity-specific management plans for public use, land use, or other management activities when only minor changes are planned. Examples could include an amended public use plan or fire management plan,"* is applicable to implementation to the proposed action.

Consistent with Categorical Exclusion (516 DM 6, Appendix 1 Section 1.4 B (10)) the HMP is a step-down management plan which provides guidance for implementation of the general goals, objectives, and strategies established in the CCP, serving to further refine those components of the CPP specific to habitat management. This HMP does not trigger an Exception to the Categorical Exclusions listed in 516 DM 2, Appendix 2.

Minor changes or refinements to the CCP in this activity-specific management plan include:

- Habitat management objectives are further refined by providing numerical parameter values that more clearly define the originating objective statement.
- Habitat management objectives are restated so as to combine appropriate objectives or to split complicated objectives for improved clarity in the context of the HMP.
- Specific habitat management guidance, strategies, and implementation schedules to meet the CCP goals and objectives are included (e.g., location, timing, frequency, and intensity of application).
- All details are consistent with the CCP and serve to provide the further detail necessary to guide the refuge in application of the intended strategies for the purpose of meeting the habitat objectives.

Permits/Approvals.

Endangered Species Act, Intra-Service Section 7 Consultation was conducted during the CCP process for Bayou Sauvage NWR.

"The proposed action would result in the implementation of the preferred alternative developed during the preparation of the Comprehensive Conservation Plan (CCP) for Bayou Sauvage NWR, a 24,293-acre refuge in Orleans Parish, Louisiana. Upon approval of the CCP, the following uses on the refuge will be implemented for a period of 15 years: recreational hunting, recreational fishing, boating, wildlife observation, and wildlife photography. The preferred alternative identified in the CCP is to restore and improve ecological diversity and augment visitor services. This alternative supports the purposes for which the refuge was established:

(1) to enhance the populations of migratory, shore, and wading birds within the refuge; (2) to encourage natural diversity of fish and wildlife species within the refuge; (3) to protect the endangered and threatened species and otherwise to provide for the conservation and management of fish and wildlife within the refuge; (4) to fulfill the international treaty obligations of the United States respecting fish and wildlife; (5) to protect the archeological resources of the refuge; (6) to provide opportunities for scientific research and environmental education, with emphasis being given to ecological and other values of wetlands; and (7) to provide opportunities for fish and wildlife oriented public uses and recreation in an urban setting. 100 Stat. 3590, dated Nov. 10, 1986. "the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations contained in various migratory bird treaties and conventions" 16 U.S.C. 3901(b), 100 Stat. 3583 (Emergency Wetlands Resources Act of 1986).

"(1) to protect, enhance, restore, and manage an appropriate distribution and diversity of wetland ecosystems and other habitats for migratory birds and other fish and wildlife in North America; (2) to maintain current or improved distributions of migratory bird populations; and (3) to sustain an abundance of waterfowl and other migratory birds consistent with the goals of the North American Waterfowl Management Plan and the international obligations contained in the migratory bird treaties and conventions and other agreements with Canada, Mexico, and other countries" 16 U.S.C. 4401 2(b) (North American Wetlands Conservation Act 1986)

In addition to the specific purposes that were established for each refuge, the National Wildlife Refuge System Improvement Act provides clear guidance for the mission of the Refuge System and priority wildlife-dependent public uses. The Improvement Act states that each refuge will:

- Fulfill the mission of the Refuge System;
- Fulfill the individual purposes of each refuge;
- Consider the needs of wildlife first;
- Fulfill requirements of comprehensive conservation plans that are prepared for each unit of the Refuge System;
- Maintain the biological integrity, diversity, and environmental health of the Refuge System; and
- Recognize that wildlife-dependent recreation activities, including hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation are legitimate and priority public uses; and allow refuge managers authority to determine compatible public uses.

Four listed species were found to be at Bayou Sauvage NWR: Endangered species found to be present on the refuge were: Brown Pelican *(Pelecanus occidentalis)* (now delisted) and West Indian Manatee *(Trichechus manatus)*. Threatened species at Bayou Sauvage NWR were: Gulf Sturgeon *(Acipenser oxyrinchus desotoi)*, and Bald Eagle *(Haliaeetus leucocephalus)* (now delisted). The determination was a concurrence, for all four listed species, that "the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources."

Public Involvement/Interagency Coordination.

The proposed HMP is a step-down of the approved CCP for Bayou Sauvage NWR. The development and approval of the CCP included appropriate NEPA documentation and public involvement. An EA was developed (USFWS 2009b) which proposed and addressed management alternatives and environmental consequences. Public involvement included public notification and a public scoping meeting held in 2007, at the Resurrection of Our Lord Church conference room in New Orleans, Louisiana. A total of 13 people in total attended the meeting. In addition, after the publication of the Draft CCP/EA in 2008, public comments were solicited and received from April 28 to May 27, 2009. Comments received are documented in the Bayou Sauvage National Wildlife Refuge Comprehensive Conservation Plan (USFWS 2009a).

Supporting Documents. Supporting documents for this determination include relevant office file material and the following key references:

Bayou Sauvage NWR Draft Comprehensive Conservation Plan and Environmental Assessment (USFWS 2009b; on file at SELA NWRC Headquarters Office in Lacombe, Louisiana)

Refuge Manager — date: 3/19/2013

Project Leader — date: 3/25/13

Regional Refuge NEPA Coordinator — date: 04/10/2013

Regional Chief, Southeast Region — date: 4/8-13

Habitat Management Plan for
Bayou Sauvage National Wildlife Refuge

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